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THE LIFE HISTORIES OF THREE TREMATODES, PARASITIC IN BIRDS AND MAMMALS, BELONGING TO THE GENUS PLAGIORCHIS*

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INTRODUCTION

Xiphidiocercariae of the Polyadena group (Sewell, 1922) have been found in relatively large numbers in the snail, *Stagnicola emarginata angulata* (Sowerby), collected at the University of Michigan Biological Station at Douglas Lake. The species occurring most frequently was determined experimentally to be the larval stage of *Plagiorchis muris* Tanabe, 1922. In certain areas almost all of the snails of this species were found to be infected with this cercaria. Another species has been found to be the larval stage of *Plagiorchis micracanthos* Macy, 1931. The third species and the least common of the three, identified as *Cercaria polyadena* Cort, 1914, has been found to be the larval stage of *Plagiorchis proximus* Barker, 1915.

The life cycle of one of the above mentioned species, *P. muris,* has been previously reported (Tanabe, 1922) from Japan. The same species in this country is found in different hosts and it is necessary to add certain morphological points in some of the stages in the life cycle.

METHODS

Snails infected with the Xiphidiocercariae were selected from the general collections made by the group in the laboratory. Identification of the species was made by careful morphological studies and measurements. The measurements were obtained by averaging those taken from cercariae that had been killed by heat. This method gave less variation than the use of several killing fluids that were tried. After identification the cercariae were placed with various organisms in an attempt to find a suitable second intermediate host and insects were suspected, because the

* A contribution from the University of Michigan Biological Station. The writer wishes to express his appreciation to Dr. W. W. Cort for helpful suggestions and to Dr. Ralph W. Macy for slides of *Plagiorchis micracanthos.*

stylets of these cercariae are large, heavy walled and have large shoulders. Experiments showed that numerous species of insects, *i.e.*, chironomids, mayflies, dragonflies and mosquitoes, could serve as second intermediate hosts. In the experimental feedings dragonflies and mosquitoes were usually used. In general the former gives better results because of the larger size and the ability to carry heavier infections of metacercariae. The dragonfly naiads used in the experiments were obtained from Vincent Lake, which is mollusc-free, and the mosquito larvae were laboratory bred. Mosquito larvae that were not used in the infection experiments made excellent food for the experimentally infected dragonfly naiads.

After penetration and encystment it was found that it was necessary for the metacercariae to mature for some time before they became infective. Metacercariae less than 48 hours old did not produce infections in the definitive hosts. Week-old metacercariae were found to be suitable for feeding experiments. In these feeding experiments a variety of animals were tried and the adults were found to develop in birds and mammals.

OBSERVATIONS ON THE PENETRATION OF XIPHIDIOCERCARIAE

One advantage found in using the mosquito larvae for infections was that the process of penetration could be easily observed. It was discovered that if young mosquito larvae were placed in a drop of water containing cercariae, then held in place by a coverslip, observations could be made with the 16 and 4 mm. lenses. This same procedure was tried as a laboratory exercise in helminthology and it gave excellent results.

The following points were observed during the process of penetration. It is doubtful if the cercaria is actually attracted by the larva but when it comes in contact with spines or the cuticle its actions become purposeful at once. By the use of the two suckers it "inches" over the surface. During the crawling movements the cercaria begins to make exploratory scrapings with the stylet. When a suitable location is found the act of penetration begins. Often the cercaria chooses a point between segments or at the base of a spine, but not necessarily so. The use of the stylet in the act of penetration is shown in Figure 1. Normally the stylet is carried in a relatively horizontal position, shown in dotted lines in the figure. When the stylet is to be brought into position for use, the posterior end is pulled dorsally and toward the anterior end through an arc of about 45 degrees. A point in the region of the shoulders of the stylet seems to act as a fulcrum. This means that the anterior tip of the stylet is forced back toward the opening of the oral sucker. From this position (see fig.) the organ is then ready to operate. With a downward and forward thrust the dorsally curved point seems to scratch the surface

of the cuticle. When this method is used the oral sucker is firmly attached and helps hold the stylet tightly against the cuticle. Sometimes, however, the acetabulum is used to hold the cercaria in place and the entire anterior end is used in a "rooting" motion to scarify the cuticle. After several scratching movements, the number depending upon the thickness of the cuticle, a slit is produced. When this opening is about one half to three fourths of the body diameter, the anterior end of the cercaria is forced through. When about the first quarter of the body has been forced through the opening, the tail is discarded. The body continues to work its way through the slit and then the tailless cercaria moves actively through the tissues. This exploration by the cercaria may be quite extensive. When a suitable place for encystment is located the cercaria takes a C-like position and encysts. The secretory processes, believed to take place around the stylet during penetration and over the surface of the body during encystment, were not seen.

THE LIFE CYCLE OF *Plagiorchis muris* TANABE, 1922

In the previous report on the life cycle of this species, from Japan, *Lymnea pervia* served as the first intermediate host. One of the most interesting points brought out in the life cycle was the fact that this species has a precocious development of the metacercariae inside the sporocyst, evidently without emergence from the snail. With the cercariae that did emerge experimental infections were obtained in chironomid larvae. Mice were experimentally infected with both types of cysts and wild rodents were found to be naturally infected.

Generally speaking, this author's experiments confirm the life cycle as given by Tanabe. It is desirable to give some additional points on the morphology of the different stages and additional hosts, found in the United States.

In this country the snail, *Stagnicola emarginata angulata,* serves as the first intermediate host. The sporocysts (fig. 2) were found to average 1.08 × 0.25 mm., slightly smaller than those described previously. Numerous cases of precocious development of the metacercariae within the sporocysts were observed. The number of snails having these metacercariae is variable and the controlling factor is unknown. It was observed that if any cysts were found at all the snail was usually heavily infected with them. In one collection, where the percentage of infection with this species of cercaria was high, some 109 snails showing the cercariae of this species were examined. Of this number 24 contained metacercariae, *i.e.,* 22 per cent of the snails giving off cercariae also had metacercariae. Attempts to get the cercaria to penetrate into the snail failed. This fact, coupled with the fact that the metacercariae are found inside the sporocysts, indicates that this condition is due to a failure of the cercariae to emerge.

Observations made on the cercaria (fig. 3) vary in some details from those reported by the previous author. In the method of measurement used in this case the body measures 0.240 × 0.092 mm., the tail 0.190 × 0.027 mm., the oral sucker 0.053 mm. in diameter, the acetabulum 0.033 mm. in diameter and the stylet 0.033 mm. long. The body is filled with a large number of large, refractile concretion granules. These granules make it difficult to see the minute details. The pharynx is visible a short distance posterior to the oral sucker, and in some specimens the intestinal ceca can be seen extending back to the posterior part of the body. The excretory bladder is Y-shaped and thick walled. It is difficult to see the rest of the system but the fragmentary parts that were observed suggest that it is the same as that given for *Cercaria polyadena* Cort (1919). The appearance of the excretory system in the latter stages (fig. 5) tends to confirm this conclusion. The number of stylet glands is difficult to determine but there seem to be seven or eight pairs, rather than the four pairs shown by Tanabe. The bundles of ducts extending to the region of the stylet are large and quite noticeable.

Soon after encystment the concretions collect in the excretory bladder. The mature cyst (fig. 4) measures about 0.2 mm. in diameter. The stylet is no longer attached to the body but remains loose inside the cyst and is often useful in determining the species in this stage. During the process of maturation the metacercaria increases somewhat in size but this and the collection of the concretions in the bladder are the only obvious evidences of development. Metacercariae that are one week old or more are infective.

In the feeding experiments it was found that development took place with facility in man, rat, mouse and pigeon. Cysts from naturally infected snails and experimentally infected insect naiads were both used in the infection experiments. The number of cysts given was never counted but was estimated to be 50 to 250 cysts. In mice 2 to 62 trematodes were recovered from a single feeding. In a rat 170 trematodes were recovered and in pigeons 6 to 17 adults were found. Natural infections of the species have been found locally in the robin, herring gull, night-hawk and spotted sandpiper.

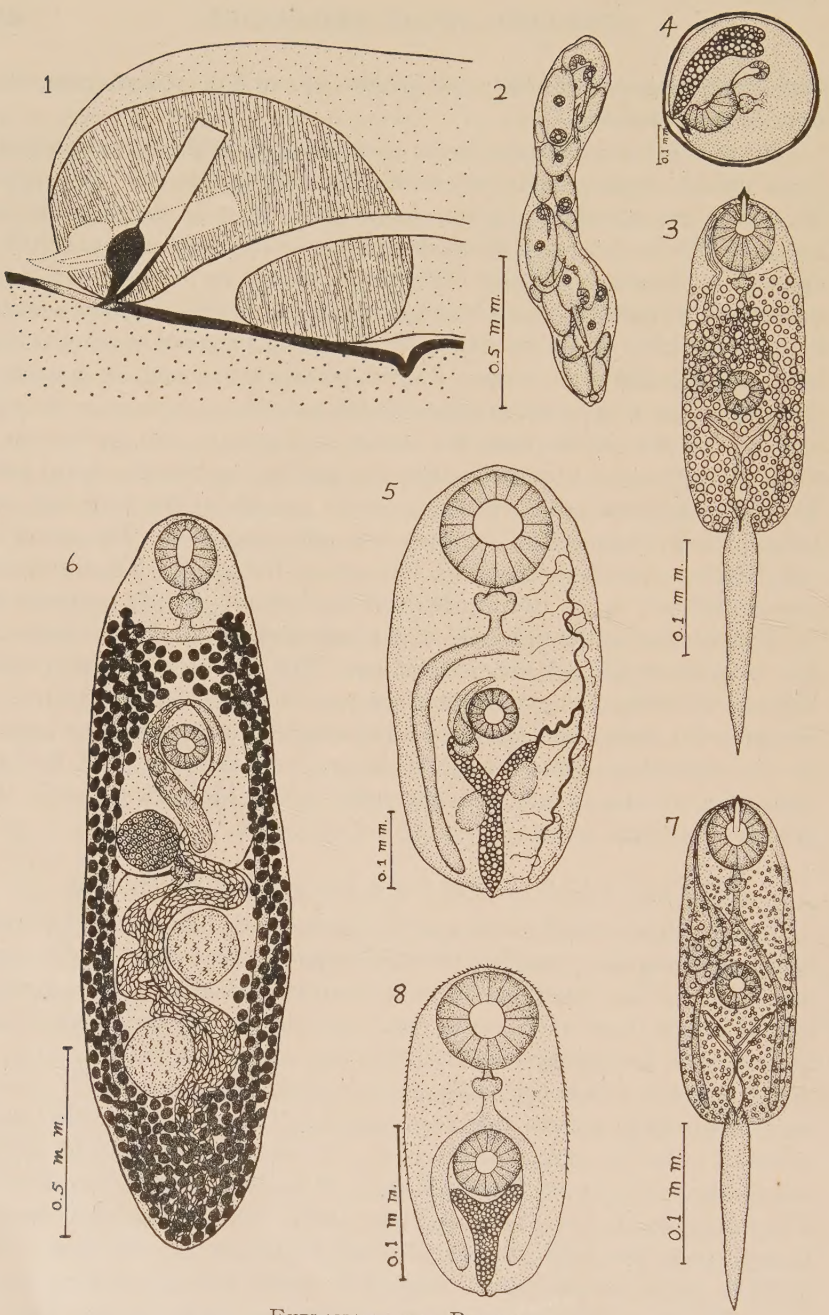
The adults develop rapidly and produce eggs in 7–9 days after infection. The infection seems to remain for about a month, as shown in a previous paper (McMullen, 1937). The eggs are passed in the morula stage and an attempt was made to get fully developed miracidia. Tanabe reports that the fully developed miracidium is produced in 96 hours. Eggs from the American species, from man, kept at about prevailing temperatures of August and September did not produce miracidia in less than 24 days. At the end of that time the yolk cells had been well used up and the cell mass had nearly developed into a miracidium. The cul-

tures containing the eggs were lost at this point and the mature miracidia were never observed.

Morphological differences in the trematodes from these experimental hosts are not obvious. The only noticeable difference is that those from the pigeon average about 0.5 mm. longer than those of the same age in rodents. The structure of the adult (fig. 6) of *P. muris,* as observed by the author, agrees essentially with that described by Tanabe and with the additional notes given by Yamaguiti (1933), but is refigured here to bring out certain details in structure. In fixed, flattened specimens the body averages 2.67×0.52 mm., the oral sucker 0.213 mm. in diameter, the acetabulum 0.144 mm. in diameter, the pharynx 0.107 mm. wide, the ovary 0.196 mm. in diameter, the anterior testis 0.231 mm. in diameter, the posterior testis 0.252 mm. in diameter and the eggs 0.038×0.019 mm. The intestinal ceca extend to the posterior portion of the body but are difficult to find because the vitellaria are quite numerous. The cirrus is well developed and extends to the left side of the ovary. The testes are placed obliquely in the third quarter of the body or slightly posterior to it. The ovary is on the right side of the body and about half way between the anterior testis and the acetabulum. The uterus is broad, passes between the testes and extends into the posterior region of the body. A metraterm is rather well developed and extends to the posterior border of the acetabulum. The excretory bladder is Y-shaped and by the impregnation of the system with mercurial salts (McMullen, 1936) the pattern was found to be $2(3+3+3)+(3+3+3)$.

THE LIFE CYCLE OF *Plagiorchis micracanthos* MACY, 1931

In a relatively small number of the same species of snail (*Stagnicola emarginata angulata*) another cercaria, quite similar to that of *P. muris* was found. This cercaria develops in sporocysts which in general appearance look like those of *P. muris* (fig. 2). They are, however, considerably smaller, averaging 0.648×0.127 mm. The cercaria (fig. 7) is a rather sluggish swimmer and emerges from the snail in the early morning. It is slightly smaller than the cercaria of *P. muris* but the difference is hardly of use in routine identification. The body is covered with spines which are sparse at the posterior end. It measures 0.232×0.082 mm. The tail, typical in form, is 0.144×0.023 mm. The oral sucker is larger, 0.044×0.049 mm., than the acetabulum, 0.033 mm. in diameter. The stylet is similar in structure to that of *P. muris* but it is shorter, 0.030 mm. The digestive and excretory systems are similar to that seen in *P. muris.* There are eight pairs of stylet glands but the ducts are not as large as in the previous form. The most obvious difference between the two cercariae is the character of the concretions. In this species the concretions are numerous but quite small and they often appear to clump together.



EXPLANATION OF PLATE

Fig. 1. Diagram illustrating the use of the stylet of a Xiphidiocercaria penetrating into a second intermediate host.
Fig. 2. Mature sporocyst of *Plagiorchis muris.*
Fig. 3. Cercaria of *Plagiorchis muris.*
Fig. 4. Metacercaria of *Plagiorchis muris.*
Fig. 5. Young *Plagiorchis muris* from pigeon, showing the excretory pattern.
Fig. 6. Adult of *Plagiorchis muris* from mouse, 8 days old.
Fig. 7. Cercaria of *Plagiorchis micracanthos.*
Fig. 8. Excysted metacercaria of *Plagiorchis proximus,* showing spination.

The cercariae were found to penetrate actively into insect larvae, as in the former case, but encystment within the sporocyst has never been found. The cysts increase somewhat in size as they mature but there is no noticeable change in the organs, except that the bladder becomes filled with concretions (fig. 8). Metacercariae that are at least a week old were found to be infective. These mature cysts measure about 0.13 mm. in diameter. The somewhat smaller size of the cyst and the presence of a smaller stylet serves to distinguish this metacercaria from the preceding species.

Mature metacercariae were fed to mice, rats and pigeons and adult flukes were recovered from mice 16 days after infection. Repeated attempts to infect rats and pigeons gave negative results. In two experimental mice, fed a hundred or more cysts and left long enough for the trematodes to reach maturity, there were 55 and 69 adults respectively. These adults were identified as *Plagiorchis micracanthos* Macy, 1931, described from bats. The eggs are in the morula stage, as they were in *P. muris*.

To date a natural infection in local bats has not been found. The rather low incidence of the infection in the snails that were collected in the region seems to indicate that the infection in the bats is rather light. Further host examinations will probably show naturally infected definitive hosts.

THE LIFE CYCLE OF *Plagiorchis proximus* BARKER, 1915

In certain areas a small number of snails of the species *Stagnicola emarginata angulata* were found to be infected with a cercaria that was identified as *Cercaria polyadena* Cort, 1914, the type species of the Polyadena group (Sewell, 1922) of Xiphidiocercariae. The morphological details of this species have been described previously by Cort (1914, 1919). Average measurements, in this case obtained from cercariae that had been killed with heat, are as follows: body 0.240 × 0.092 mm., tail 0.190 × 0.027 mm., oral sucker 0.053 mm. in diameter, acetabulum 0.038 mm. in diameter and the stylet 0.030 mm. in length. The species is distinguished from the two previous species by the clearness of the body, due to the scarcity of concretion granules. Slight differences in dimensions, which will be found by comparing this species with the other two, are not useful in routine identification.

The average size of the sporocyst of this species is intermediate to the other two species, 1.021 × 0.243 mm. In appearance and in general structure it is quite similar to the other species.

The cercariae penetrate actively into chironomid, dragonfly, mayfly naiads and mosquito larvae. It will also penetrate into tadpoles, snails and small fish but the metacercariae were found to die soon after encyst-

ment. In the insect hosts the metacercariae must mature several days before they become infective, so it is probable that the other animals do not serve as natural vectors. In one snail, however, metacercariae were found in the sporocysts containing cercariae of this species. It is probable, therefore, that this species also has the precocious development of the metacercariae in the sporocysts without emerging from the snail, as in *P. muris*. The mature, infective cysts measure about 0.13 mm. in diameter and resemble those of *P. micracanthos* so closely that it is impossible to distinguish them unless the metacercariae are excysted. The cuticular spines on the body of the metacercaria of *P. micracanthos* extend nearly to the posterior end while the spines of *P. proximus* extend over the anterior two thirds of the body (fig. 8).

Mice were the only experimental animals that became infected with the adult flukes. Even these hosts seem refractive because never more than six trematodes were obtained, usually only one or two, and often the mice were negative. The few adults obtained were identified as *P. proximus* Barker, 1915. Two muskrats, out of several captured in the region, had very light infections of the same species. The egg is in the same stage as that seen in the other species.

With the completion of this life cycle it should be stated that *Cercaria Plagiorchis proximus* (= *Cercaria polyadena* Cort, 1914) is the type species of the Polyadena group of the Xiphidiocercariae. This type of Xiphidiocercaria seems to be characteristic of the members of the genus *Plagiorchis* and closely related genera. A complete discussion of the taxonomy of these three species, and others whose life histories are known to have Xiphidiocercariae, follows in a later paper.

SUMMARY

1. The adults of three species of trematodes belonging to the genus *Plagiorchis, i.e., P. muris, P. Micracanthos* and *P. proximus,* have been obtained in experimental infections.

2. The first intermediate host for the three species has been found to be *Stagnicola emarginata angulata.*

3. Usually the second intermediate hosts were aquatic insects. The precocious development of the cercariae into metacercariae without leaving the sporocyst was observed in *P. muris* and *P. proximus.*

4. The adults of *P. muris* were obtained in experimental infections of man, rat, mouse and pigeon. Natural infections were found in the night-hawk, robin, herring gull and spotted sandpiper.

5. Adults of *P. micracanthos,* a bat parasite, have been obtained in experimental mice.

6. Adults of *P. proximus,* a parasite in the muskrat, have been obtained in small numbers in experimental mice.

LITERATURE CITED

Barker, F. D. 1915.—Parasites of the American muskrat (*Fiber zibethicus*). Jour. Parasit., 1: 192.

Cort, W. W. 1914.—Larval trematodes from North American fresh-water snails. Jour. Parasit., 1: 65–84.

1919.—The excretory system of a stylet Cercaria. Univ. Calif. Publ. Zool., 19: 275–281.

McMullen, Donald B. 1936.—A note on the staining of the excretory system of trematodes. Trans. Amer. Micro. Soc., 55: 513–515.

1937.—An experimental infection of *Plagiorchis muris* in man. Jour. Parasit., 22: 113–115.

Macy, Ralph W. 1931.—New bat trematodes of the genera *Plagiorchis, Limatulum,* and *Dicrocoelium.* Jour. Parasit., 18: 28–33.

Sewell, Seymour. 1922.—Cercariae Indicae. Ind. Jour. Med. Res., 10: 1–372.

Tanabe, H. 1922.—A contribution to the study of the life cycle of hermaphroditic distomes. A study of a new species *Lepodermus muris* n. sp. Okayoma Igakkai Zasshi, 47–68. (Japanese.)

Yamaguiti, S. 1933.—Studies of the Helminth fauna of Japan. Part I. Trematodes of birds, reptiles and mammals. Jap. Jour. Zool., 5: 1–134.

A DISCUSSION OF THE TAXONOMY OF THE FAMILY PLAGIORCHIIDAE LÜHE, 1901, AND RELATED TREMATODES*

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INTRODUCTION

The classification of the members of the family Plagiorchiidae Lühe, 1901, in fact that of nearly all the major groups of trematodes, is based upon adult characters. There is considerable evidence that adult characters may be quite misleading, unless used in conjunction with some knowledge of the larval and developmental stages. The use of one adult character by one author and a different character by another has led to the placing of the same species in different families. This leads one to conclude that the exclusive use of adult characters for the classification, especially from preserved material alone, leaves much to be desired.

The existing classification in some groups of trematodes seems logical. In others, as our knoweldge accumulates, it is obviously confused or superficial. From the beginning the discovery of characters which are of major importance in determining the boundaries of the larger groups, and those important in determining the relationship of the smaller groups, has been by a process of eliminatioin. In this connection Cort (1917), Faust (1919), La Rue (1926) and other workers have suggested that the characteristics of the excretory system and the larval stages are significant in developing a natural classification. The use of the larval characters and the excretory system has been of unquestionable value in the suborder Strigeata La Rue, 1926. Later work seems always to indicate that these earlier conclusions are basically sound.

In the Plagiorchiidae and related families a situation has arisen, which seems to be similar to that leading to the establishing of the Strigeata. Pagenstecher (1857) was the first to link certain types of cercariae, now known as Xiphidiocercariae, with certain species of adult trematodes. His conclusions were based on comparative morphology and some uncontrolled feeding experiments. Similar work was done by his contemporaries and others in the period from 1860–1900. The knowledge of comparative morphology was the guiding influence in this work. Much of it is of value in that the cercariae were assigned, more

* A contribution from the University of Michigan Biological Station and the Department of Helminthology of the School of Hygiene and Public Health of the Johns Hopkins University. The writer wishes to express his appreciation to Dr. W. W. Cort, Dr. George R. La Rue and Dr. E. W. Price for helpful criticisms and suggestions.

or less correctly, to major groups of trematodes. The use of morphology was, and still is, important in the study of trematodes and their larval stages, but an experimental attack on the life cycles has gradually come into its own. As the knowledge of life histories increased it became more and more evident that each major group of the trematodes probably has a particular larval type.

It was von Linstow (1890), Sinitsin (1905, 1907), Magath (1917) and McCoy (1928) who ushered in the modern experimental life history work on Xiphidiocercariae. In the following up this idea, that larval stages are important in classification of these trematodes, Talbot (1933, 1934), Byrd (1935) and McMullen (1935b) have shown that larval characters are important in demonstrating the close relationship of the members of the Reniferinae and Telorchiinae. McMullen (1935c) also points out that the larval stages of *Macroderoides typicus* and *Alloglossidium corti* indicate that they should be included in the family Plagiorchiidae, rather than in the Allocreadiidae. These are specific examples of the assistance a knowledge of larval characters has given in making possible a more natural classification of those trematodes having Xiphidiocercariae.

With this in mind a survey was made of the life histories to be found in the literature. It was found that 35 complete or partially completed life cycles of Xiphidiocercariae have been reported (table 1). This is a very small percentage of the known species that probably belong in the Plagiorchiidae and related families. A comparative study of these life cycles was made, to see if there was a possible skeleton to which taxonomic flesh could be attached. As a result of this comparative study it seems advisable to suggest the use of larval characters as a foundation on which to base the superfamily Plagiorchioidea Dollfus, 1930. It is to be revised to include all trematodes that develop from Xiphidiocercariae.

DISCUSSION

Out of the author's interest in a wide variety of Xiphidiocercariae and the life histories of numerous trematodes having this cercarial type, there has grown a conviction that these trematodes are related. If this be true one should find morphological evidence of this relationship in the various stages of the known life cycles. If such evidence exists it should be expressed in the classification of these trematodes.

With this idea in mind a comparison was made of the 35 species with Xiphidiocercariae whose life histories are at least partially known. They represent 20 different genera, 8 subfamilies and 3 families. The three families represented include the Plagiorchiidae, Lecithodendriidae and Lissorchiidae. As would be expected the members of these groups of trematodes show diverse adult characters. On the other hand they have

TABLE I.—*Known trematode life histories which include Xiphidiocercariae*

Species	Definitive hosts	1st intermed. hosts	2nd intermed. hosts	Authors
1. Plagiorchis muris Tanabe, 1922	Mouse, Rat Pigeon, Man	Lymnae pervia Stagnicola emarginata	L. pervia S. emarginata Insect naiads	Tanabe (1922) McMullen (1937)
2. Plagiorchis maculosis (Rudolphi) Braun, 1901	Insectivorius birds	Lymnea stagnalis	Chironomids	Noller and Ullrich (1927)
3. Plagiorchis ramlianus Looss, 1896	Toads	Bulinus contortus	Snails Insect naiads	Azim (1935)
4. Plagiorchis micracanthos Macy, 1931	Bats Mouse	Stagnicola emarginata	Insect naiads	McMullen (1937)
5. Plagiorchis proximus Barker, 1915	Muskrat Mouse	Stagnicola emarginata	Insect naiads S. emarginata	McMullen (1937)
6. Opisthioglyphe ranae (Frölich) Looss, 1907	Rana sp. Bufo sp.	Lymnea stagnalis L. pallustris	Tadpoles	Sinitsin (1905)
7. Opisthioglyphe rastellus (Olsson) Looss, 1907	Rana sp. Bufo sp.	Lymnea stagnalis L. pallustris	Tadpoles, other amphibian larvae	Joyeux and Baer (1927)
8. Eustomos chelydrae MacCallum, 1921	Turtles	Heliosoma antrosa S. emarginata L. stagnalis B. megasoma	Snails Dragonfly Mayfly Chironomids	Krull (1934) McMullen (1935)
9. Alloglossidium corti (Lamont) Van Cleave, 1934	Ameiurensis natalis	Heliosoma trivolvis H. campanulata	Crayfish Dragonfly Mayfly	McCoy (1928) McMullen (1935)
10. Macroderoides typicus (Winfield) Van Cleave, 1932	Amia calva	H. campanulata H. trivolvis	Tadpoles	McMullen (1935)
11. Lissorchis fairporti Magath, 1917	Ictiobus	H. trivolvis	Chironomids	Magath (1917)
12. Haplometra cylindracea (Zeder) Odhner, 1911	Rana sp. Bufo sp.	Lymnea ovata	Illybius Water beetle	von Linstow (1890)
13. Ostiolum mediopiexus (Stafford) Ingles, 1933	Rana pipiens	Planorbula armigera	Dragonfly Sympetrum	Krull (1930)
14. Ostiolum complexus Seely, 1906	R. clamitans R. catesbeiana R. pipiens	Pseudosuccinea columella	Dragonfly Sympetrum Holotania Pachydiplax	Krull (1933)
15. Ostiolum orchorchis Ingles, 1932	Rana aurora	Heliosoma parvus H. vermicularis	Dragonfly Sympetrum Plathemis	Ingles (1933)
16. Haematoloechus variegatus (Rudolphi) Ingles, 1933	Rana sp.	Unknown	Damselfly Calopteryx Anopheles maculipennis	Sinitsin (1907) Van Theil (1930)

TABLE 1.—*Continued*

Species	Definitive hosts	1st intermed. hosts	2nd intermed. hosts	Authors
17. Haematoloechus parviplexus (Stafford) Ingles, 1933	Rana clamitans	Gyraulus parvus	Dragonfly Sympetrum	Krull (1930)
18. Haematoloechus longioplexus Stafford, 1902	Rana catesbeiana	Unknown	Damselfly	Krull (1932)
19. Prosthogonimus pellucidus (von Linstow) Braun, 1901	Chickens	Unknown	Dragonfly	Kotlan and Chandler (1927)
20. Prosthogonimus macrorchis Macy, 1934	Chickens	Amnicola limnosa	Dragonfly	Macy (1934)
21. Renifer kansensis Crow, 1913	Snakes	Physella sp.	Tadpoles	McCoy (1928)
22. Renifer aniarium Leidy, 1890	Natrix	Physa helei	Tadpoles	Byrd (1935)
23. Dasymetra conferta Nicoll, 1911	Natrix	Physella sp.	Tadpoles	McCoy (1928)
24. Dasymetra villicea Byrd, 1935	Natrix	Physa helei	Tadpoles	Byrd (1935)
25. Pneumatophilus variabilis (Leidy) Odnner, 1910	Gartersnakes	Physella sp.	Tadpoles	McCoy (1928)
26. Lechriorchis primus Stafford, 1905	Gartersnakes	Physella parkerii	Tadpoles	Talbot (1933)
27. Lechriorchis tygarti Talbot, 1933	Gartersnakes	Physella gyrina	Tadpoles	Talbot (1933)
28. Zeugorchis synomentera Sumwalt., 1926	Gartersnakes	Physella gyrina	Tadpoles	Ingles (1933)
29. Zeugorchis eurinus (Talbot) Price, 1936	Gartersnakes	Physella gyrina	Tadpoles	Talbot (1933)
30. Cercorchis medius (Stunkard) Perkins, 1928	Turtles	Physella integra	Tadpoles	McMullen (1935)
31. Cercorchis robustus (Goldberger) Perkins, 1928	Turtles	Pseudosuccinea columella	Snails	Krull (1935)
32. Lecithodendrium chilostomum (Mehlis) Looss, 1907	Bats	Unknown	Phrygenea grandis	Brown (1933)
33. Mosesia chordeilesia McMullen, 1935	Night-hawk Martin	Unknown	Mayfly	McMullen (1936)
34. Plagitura parva Stunkard, 1933	Triturus viridescens	Heliosoma antrosa	Dobsonfly Snails	Stunkard (1933)
35. Maritrema rhodanicum Carrère, 1936	Larus argentatus	Paludestrina acuta Pseudammonicola similis	Gammarus pulex	Carrère (1936)

certain larval characteristics in common and this fact probably indicates that they are related. The morphology of the excretory system has played an important role in the existing classification of these trematodes. It has been found that the flame cell pattern in the cercariae and in the adults is quite variable. The excretory bladder varies in form, being a short bag-shaped vesicle, I-shaped, Y-shaped or V-shaped. This indicates that the excretory system should be considered of secondary importance in outlining the boundaries of the major group. It is believed that the excretory system is of prime importance in separating the larger group into natural subgroups. Not enough is known about the miracidia of these trematodes to make a statement regarding their morphology and use in the taxonomic scheme.

It is difficult to present a detailed comparison of these 35 species. To facilitate matters a thumbnail sketch of what is known about each life cycle is given in the accompanying table. The plate is an attempt to give a pictorial representation of the possible lines of development and the relationships of the families, subfamilies and genera to be included in the superfamily Plagiorchioidea.

As stated above the families Plagiorchiidae, Lecithodendriidae and Lissorchiidae are to be included in the superfamily. In the Lissorchiidae there is only one species, *Lissorchis fairporti* Magath, 1917 (fig. 5). The characters upon which the family was separated from the other groups, i.e., a marginal genital pore situated below the acetabulum and a lobed ovary, may or may not be of major importance. However, until more is known of the life cycles of related trematodes the final status cannot be determined. At present it seems that this species is closely related to the genera *Alloglossidium* and *Macroderoides,* which are also fish parasites. The species is known to have a Xiphidiocercaria and this is sufficient evidence that it should be included in the superfamily Plagiorchioidea. The status of the family is accepted tentatively, until additional knowledge is available.

The knowledge of the life cycles of the members of the Lecithodendriidae Odhner, 1910, is meager but there seems to be no doubt that the cercariae of these trematodes are Xiphidiocercariae with V-shaped excretory bladders, similar to those found in the adults. The partial life cycles of two species of this family, *Lecithodendrium chilostomum* (Mehlis) Looss, 1907, and *Mosesia chordeilesia* McMullen, 1936, one in each of the two subfamilies, are known. A composite diagram of these species is shown in Figure 12. With this evidence it is suggested that the Lecithodendriidae be considered a family under the Plagiorchioidea, basing the change upon the fact that these trematodes have Xiphidiocercariae. The characteristics of the cercariae, so far as known, should be added to the diagnosis now given for the family.

The family Plagiorchiidae, as it exists, is a large group containing hundreds of described species. As would be expected in such a large group the divergence of species is quite marked and because of these variations in adult characters it is difficult to determine the criteria to be used in obtaining a natural classification. This confusion has been illustrated in a previous paper (McMullen, 1935c) with certain trematodes which have been placed in the Allocreadiidae, on the basis of character of the bladder in the adults. It is obvious that such a large group as the Plagiorchiidae would have natural subdivisions. On the basis of adult characteristics about 10 subfamilies and some 60 genera have been established. In the present discussion, revision will be suggested only for those groups in which there is sufficient knowledge of the life history and the excretory system.

With the creation of the superfamily Plagiorchioidea, it becomes necessary to revamp the classification of the Plagiorchiidae. The type subfamily of this group is the Plagiorchiinae. Various authors differ in the number of genera which they include in this subfamily but there are 8 to 12 of them. As is shown in the table the life histories of eight species are known, representing three different genera, *Plagiorchis, Opisthioglyphe* and *Eustomos*. Of these five are found in the type genus, *Plagiorchis, i.e., P. muris* Tanabe, 1922, *P. maculosis* (Rudolphi) Braun, 1901, *P. ramlianus* (Looss, 1896), *P. micracanthos* Macy, 1931, and *P. proximus* Barker, 1915. A diagram of the cercaria and adult types, showing the important organs, is shown in Figure 1. In the genus *Opisthioglyphe* two life cycles are known, *O. ranae* (Frölich) Looss, 1907, and *O. rastellus* (Olsson) Looss, 1907. A composite diagram of these two species is shown in Figure 2. *Eustomos shelydrae* MacCallum, 1921, (fig. 11) is at present placed in the Plagiorchiinae on the basis of larval characters.

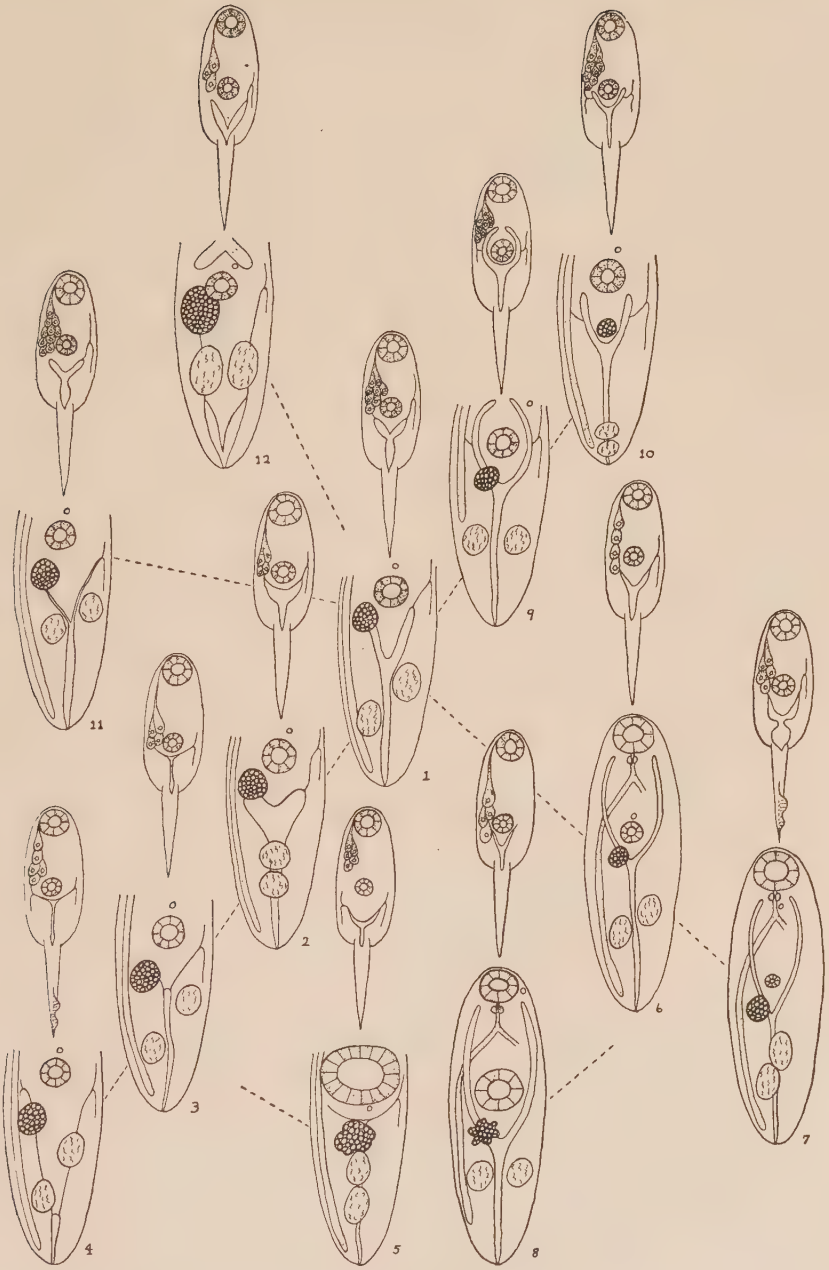
With one exception these trematodes have cercariae similar to *Cercaria polyadena* Cort, 1914. There is a well developed, Y-shaped excretory bladder and the flame cell pattern of $2(3+3+3)+(3+3+3)$ is characteristic. The one exception, *Plagiorchis ramlianus* (Looss, 1896) (= *Lepoderma ramlianum* Looss), does not compare favorably with the other members of the genus, or even members of the subfamily. Azim (1935) gives the life cycle of this form as including a stylet cercaria that develops in a redia. There seems to be a mergance of rediae and sporocysts within major groups of trematodes, but it hardly seems possible for such a wide variation within a natural genus. A more serious difficulty is found in comparing the excretory systems of the cercaria and adult with other members of the genus *Plagiorchis*. Azim states that the flame cell pattern is $2(2+2)+(3+1)=16$. This is entirely different from anything found in the genus, or even the subfamily. On the other

hand the figure of the cercaria in Azim's paper shows 18 flame cells. At present it is impossible to state what the actual status of this species should be.

With the proposal to establish the superfamily Plagiorchioidea, it is suggested that the Plagiorchiidae Lühe, 1901, be redefined and be restricted to those forms at present included in the Plagiorchiinae. The cercariae of all these species in good standing, in which the life cycle is known, belong to the Polyadena group of Xiphidiocercariae. Since this type of larva seems to be characteristic of the group it should be included in the diagnosis. These three genera are, therefore, to be considered to form the basis for the Plagiorchiidae as redefined. The other genera which are at present included in the subfamily can be retained tentatively, on the basis of adult characters. When further knowledge of their life cycles becomes available the true relationships can be determined.

The possible relationship between the genera, *Plagiorchis* (fig. 1), *Opisthioglyphe* (fig. 2), *Alloglossidium* (fig. 3), and *Macroderoides* (fig. 4) has been discussed in a previous paper (McMullen, 1935c). These genera are reproduced here in the plate to present a complete concept of all the genera involved in the revision of the classification. In the first place, similarity of the adult characters of members of *Alloglossidium* and *Macroderoides* indicates that these two genera are probably closely related. The larval stages of the two species whose life histories are known are quite similar. These trematodes have been confused with the Allocreadiidae because adult characters were used in placing them in a major group. From the structure of their larval stages we now know that they belong to the Plagiorchioidea. These closely related genera show some rather striking differences when compared with other genera of the superfamily. For this reason it is proposed that a new family, the Macroderoididae, be established for them. The cercariae of this family are characterized by the I-shaped excretory bladder and the small number of stylet glands. The adults are elongate and spined, the intestinal ceca are long, the oral sucker and acetabulum are about the same size, the genital pore is just anterior to the acetabulum and the vitellaria are heavily massed follicles. As far as known they are parasitic in the digestive tract of fish.

At present there are only two genera which can be definitely placed in this family. Undoubtedly there are other species, at present placed in the Allocreadiidae, which actually belong to the new family in the Plagiorchioidea but have been misplaced by the use of adult characters. Further evidence that the existing classification of the Allocreadiidae is an unnatural one is found in the fact that within the family there are at present three different types of larval stages (Hopkins, 1934).



EXPLANATION OF PLATE

1. Composite diagram of *Plagiorchis* species.
2. Composite diagram of *Opisthioglyphe* species.
3. Diagram of *Alloglossidium corti.*
4. Diagram of *Macroderoides typicus.*
5. Diagram of *Lissorchis fairporti.*
6. Diagram of *Haplometra cylindracea.*
7. Composite diagram of *Haematoloechus* and *Ostiolum* species.
8. Composite diagram of *Prosthogonimus* species.
9. Composite diagram of members of the Reniferinae.
10. Composite diagram of the *Cercorchis* species.
11. Diagram of *Eustomos chelydrae.*
12. Composite diagram of members of the Lecithodendriidae.

In a previous paper (McMullen, 1935b) the relationship of the Telorchiinae Looss, 1899, and Reniferinae Pratt, 1902, within the Plagiorchiidae Lühe, 1901, has been discussed. The morphology of the adults has not always led previous authors to suspect a close relationship between these two subfamilies. Fuhrmann (1928) included the genera in the subfamily in the list of genera belonging to the Plagiorchiidae. Mehra (1931) followed Perkins (1928) in making a subfamily of the group, but definitely placed the Telorchiinae in the family Plagiorchiidae. The similarity of the larval stages and the type of excretory system confirms this relationship.

The known life cycles of eleven species, belonging to these subfamilies, are shown in the table. Composite diagrams of the Reniferinae (fig. 9), including *Renifer kansensis* Crow, 1913, *R. aniarium* Leidy, 1890, *Dasymetra conferta* Nicoll, 1911, *D. villicea* Byrd, 1935, *Pneumatophilus variabilis* (Leidy) Odhner, 1910, *Lechriorchis primus* Stafford, 1905, *L. tygarti* Talbot, 1933, *Zeugorchis eurinus* (Talbot) Price, 1936, *Z. sykomentera,* Sumwalt, 1926, and the Telorchiinae (fig. 10), including *Cercorchis medius* (Stunkard) Perkins, 1928, and *C. robustus* (Goldberger) Perkins, 1928, are shown in the plate. Since there appears to be a definite relationship between these groups it is desirable to show it in the classification. It is suggested, therefore, that they be placed in the same family in the Plagiorchioidea and that the family Reniferidae Baer, 1924, be redefined to include the two subfamilies. That all the Xiphidiocercariae have long Y-shaped excretory bladders, the arms of which extend more or less around the acetabulum and in which the main excretory tubules enter the arms of the bladder posterior to the tips, is the outstanding character of the family. The diagnoses of the two subfamilies remain, as given by the authors who established them, based upon adult characters. The genera in which the life histories are not known, but which are at present included in the subfamilies, must be accepted tentatively as belonging to the Reniferidae.

The trematodes included in the table belonging to the genera *Prosthogonimus, Haematoloechus, Ostiolum* and *Haplometra* appear to be related. *Haplometra cylindracea* (Zeder) Odhner, 1911, is shown in Figure 6. The composite diagram of *Haematoloechus* and *Ostiolum,* including *H. variegatus* (Rudolphi) Ingles, 1933, *H. parviplexus* (Stafford) Ingles, 1933, *H. longioplexus* Stafford, 1902, *O. medioplexus* (Stafford) Ingles, 1933, *O. complexus* Seely, 1906, *O. orchorchis* Ingles, 1932, is shown in Figure 7 in the plate. A composite diagram of *Prosthogonimus pellucidus* (von Linstow) Braun, 1901, and *P. marcrochis* Macy, 1934, is shown in Figure 8. The cercariae of all these forms are similar and the excretory bladder develops in a characteristic way. The cercariae have a Y-shaped bladder, similar in many respects to that seen

in the Polyadena group of Xiphidiocercariae, however, it becomes much larger in the development of the adult. The bladder arms grow rapidly into the region of the bifurcation of the intestinal ceca. The position of the gonads, genital pore and other organs of the adult trematodes vary a great deal in the different genera. For this reason it is difficult to establish the relationship between these genera without a knowledge of the larval and development stages. Since these facts do indicate that these genera are all related, such a relationship should be shown in the classification of the trematodes involved. Pratt (1902) established the subfamily Haplometrinae to include the genera *Haematoloechus, Ostiolum* and *Haplometra.* Lühe (1909) established the subfamily Prosthogoniminae for *Prosthogonimus* and other related genera. In order to show the proper relationship between these two families it is suggested that a new family, Haplometridae, be established to include the Haplometrinae and Prosthogoniminae. The arrangement of the digestive system, gonads, genital pore and uterus is quite variable in the adults and these characters, as in the existing classification, are used in defining the subfamilies and genera.

The information available in the literature on the morphological details of *Plagitura parva* Stunkard, 1933, and *Maritrema rhodanicum* Carrére, 1936, is incomplete. For this reason they are not figured with the other representatives of the genera having Xiphidiocercariae. If the latter species has the "*armatae* type" of Xiphidiocercaria, as reported, this species could no longer be placed in the Heterophyidae. A more natural position would be in the Plagiorchioidea, family Lecithodendriidae.

Some interesting points in the classification of the Xiphidiocercariae themselves might be mentioned in passing. The original divisions (Lühe, 1909) of the Xiphidiocercariae were made principally on characteristics of the tail, suckers, size, and in one group, the Y-shaped excretory bladder. Sewell (1922) followed somewhat the same plan but made more accurate observations on the excretory system and other minute details of the anatomy. He was aware that the classification needed revision because he found widely divergent types within the same group. He, therefore, separatd these groups into several subgroups.

As we view this classification in the light of present knowledge of the life cycles, it is evident that in some cases unrelated cercariae have been placed together and closely related forms have been widely separated. For example, the members of the genera *Alloglossidium* and *Macroderoides* are evidently closely related. The adults are very much alike and the cercariae are similar in that they have an I-shaped excretory bladder, few glands, and suckers about the same size. The cercaria of

M. typicus is relatively large, has a well developed fin-fold on the tail and has a weak, thin walled stylet. The cercaria of *A. corti* differs in being smaller, has no fin-fold on the tail and the stylet is heavy walled with pronounced shoulders. If one uses the characteristics of the old grouping of the Xiphidiocercariae, these differences would place the cercaria of *M. typicus* in the Ornatae group and that of *A. corti* in the Microcotylae group. This wide separation of forms, which seem to be closely related, on the basis of superficial characters shows that the existing method of separating these groups cannot be used.

In the cercariae of the frog lung flukes and related forms a similar situation arises. The cercariae of these trematodes are all similar in having a large oral sucker, four pairs of stylet glands and a Y-shaped excretory bladder which goes through extensive development in the maturation of the adult. They vary in body size, arrangement of the stylet glands, character of the stylet, and all have a fin-fold on the tail except the cercaria of *Haplometra cylindracea*. Here the absence of the fin-fold would, in the present classification, eliminate this form from the Ornatae group of Xiphidiocercariae and thus separate it from closely related forms. It seems probable, therefore, that the fin-fold of the tail and other such larval modifications are of little more than specific value in the Xiphidiocercariae.

At best, classifications of cercariae on their larval characters without a knowledge of the life histories are only tentative. The groups established in such classifications are of value only when it has been shown that a certain type of cercaria is characteristic of a group of adults. The similarity in the morphology of the larvae of related trematodes is more marked than that of the adults but it is often necessary to know the life cycle before it is possible to determine which characters are of prime importance in forming natural groups. In the case of the Polyadena group of Xiphidiocercariae the morphology was worked out in detail in the type species (Cort, 1914, 1919) and for this reason it is possible to get a definite concept of this type of cercaria. That this is a natural group is borne out by the fact that the life cycles of seven members of this group show that they belong to the Plagiorchiidae Lühe, 1901, emend. Another group of Xiphidiocercariae, the Virgulae group, is probably also a natural one. No life cycle is known for any of the species but all the known cercariae are so similar that it is hard to believe that the adults will be found to be in widely divergent groups.

As was stated earlier in the paper, the number of life histories known in these groups is quite small when compared with the enormous number of trematodes included in them. However, on the basis of our present knowledge it seems feasible to suggest the use of larval characters as a basis for the superfamily Plagiorchioidea.

DIAGNOSES

In making these suggested changes only those groups in which something is known of the life cycles will be considered.

Superfamily Plagiorchioidea Dollfus, 1930, emend.

Superfamily diagnosis:—Distomata: Cercariae belong to Xiphidiocercariae Lühe, 1909, characterized by a simple stylet at anterior end, slender tail, eyespots absent, developing in sporocysts and penetrating into second intermediate hosts. Adults found in digestive, respiratory and reproductive tracts of vertebrates.

Type family:—Plagiorchiidae Lühe, 1901, emend.

This superfamily also includes the families Lissorchiidae Magath, 1917, and Lecithodendriidae Odhner, 1910. All species generally accepted as belonging to these families, whose life cycles are not known, should be tentativly included.

Family Plagiorchiidae Lühe, 1901, emend.

Family diagnosis:—Plagiorchioidea: Excretory bladder in larval and adult forms Y-shaped with main excretory tubes attached at anterior tips of arms. Cercariae belong to Polyadena group Sewell, 1922. Body of adults spined and elongated. Intestinal ceca extend into posterior end. Genital pore preacetabular and near median line. Cirrus well developed. Testes oblique and posterior to ovary. Ovary just posterior to acetabulum and lateral to median line. Vitellaria follicular and variable in extent. Uterus passes between testes into posterior end. Parasitic in the digestive tract of vertebrates.

Type genus:—*Plagiorchis* Lühe, 1899.

Family Macroderoididae n. fam.

Family diagnosis:—Plagiorchioidea: Excretory bladder in larval and adult forms I-shaped, variable in length. Cercarial stage characterized by bladder form and small number of stylet glands. Body of adults elongate and spined. Intestinal ceca extend into posterior end. Genital pore anterior to acetabulum and near median line. Cirrus well developed. Testes oblique and posterior to ovary. Ovary just posterior to acetabulum and lateral to median line. Vitellaria are massed follicles. Uterus passes between testes into posterior end. Adults parasitic in digestive tract of fish.

Type genus:—*Macroderoides* Pearse, 1924.

Family Reniferidae Baer, 1924, emend.

Family diagnosis:—Plagiorchioidea: Excretory bladder in larval and adult forms Y-shaped with main excretory tubes attached laterally and posterior to tips of arms. Cercariae with small stylets and 8–10 pairs of stylet glands. Body of adults elongate, may or may not be spined. Extent of intestinal ceca variable. Genital pore preacetabular, median or lateral. Cirrus well developed. Position of gonads variable. Vitellaria follicular and variable in extent. Uterus extends into posterior end. Adults parasitic in the digestive and respiratory tracts of reptiles.

Type genus:—*Renifer* Pratt, 1902.

Family Haplometridae n. fam.

Family diagnosis:—Plagiorchioidea: Excretory bladder in cercaria small and Y-shaped, develops in metacercaria and adult to large Y-shaped bladder extending into region of bifurcation of intestinal ceca. Cercariae small, have small number of stylet glands. Body of adults elongate or broad. Intestinal ceca extend into posterior end. Genital pore preacetabular, may be near acetabulum, lateral or near oral sucker. Cirrus present. Position of gonads variable. Vitellaria follicular and variable in extent. Uterus filled with numerous eggs and extends into pos-

terior end. Adults parasitic in respiratory tract of Amphibia and reproductive tract of birds.

Type genus:—*Haplometra* Looss, 1899.

SUMMARY

1. A comparative review of the known life cycles of Xiphidiocercariae Lühe, 1909, has been presented.

2. It has been suggested that this comparison provides sufficient evidence to warrant the recognition of the superfamily Plagiorchioidea Dollfus, 1930, emended to include all trematodes which develop from Xiphidiocercariae.

3. Sufficient evidence was found in four families to begin the reorganization within the Plagiorchioidea, but the final arrangement within the superfamily must await further information on the life cycles.

BIBLIOGRAPHY

Azim, M. Abdel. 1935.—On the life history of *Lepoderma ramlianum* Looss, 1896, and its development from Xiphidiocercaria. Jour. Parasit., 21: 365–368.

Baer, Jean G. 1924.—Description of a new genus of Lepodermatidae (Trematoda) with a systematic essay on the family. Parasit., 16: 22–31.

Brown, F. J. 1933.—On the execretory system and life history of *Lecithodendrium chilostomum* (Mehl.) and other bat trematodes, with a note on the life history of *Dicrocoelium dendriticum* (Rudolphi). Parasit., 25: 317–328.

Byrd, Elon E. 1935.—Life history studies of Reniferinae (Trematoda, Digenea) parasitic in Reptilia of the New Orleans area. Trans. Amer. Micro. Soc., 54: 196–225.

Carrère, M. Pierre. 1936.—Sur the cycle evolutif d'un *Maritrema*. Compt. Acad. Sci., 202–244.

Cort, W. W. 1917.—Homologies of the excretory system of the forked-tailed cercariae. Jour. Parasit., 4: 49–57.

1919.—The excretory system of a Stylet Cercaria. Univ. Calif. Publ. Zool., 19: 275–339.

Dollfus, Robert Ph. 1930.—Le point d'aboutissement des canaux collecteurs a la vessie chez les Distomes; son importance au point de vue systematique. Ann. Parasit., 8: 143–146.

Faust, Ernest C. 1919.—The excretory system in Digenea. II. Observations on the excretory system in Distome Cercariae. Biol. Bull., 36: 322–339.

Fuhrmann, von Otto. 1928.—Zweite Klasse des Cladus Plathelminthes Trematoda. W. Kekenthal Handbuch der Zoologie, 1–140.

Hopkins, Sewell H. 1934.—The papillose Allocreadiidae. III. Biol. Mono., 13: 1–80.

Ingles, Lloyd. 1933 (a).—Studies on the structure and life history of *Ostiolum oxyorchis* (Ingles) from California redlegged frog, *Rana aurora draytoni*. Univ. Calif. Publ. Zool., 39: 135–162.

1933 (b).—Studies on the structure and life history of *Zeugorchis synomentera* Sumwalt, a trematode from the snake, *Thamnophis ordinoides* from California. Univ. Calif. Publ. Zool., 39: 163–178.

Joyeux, Ch. and Jean G. Baer. 1927.—Reserches sur le cycles evolutif du trematode *Opisthioglyphe rastellus* (Olsson, 1876). Bull. Biol., 61: 359.

Kotlan, A. and W. L. Chandler. 1927.—On the role played by dragonflies in the transfer of *Prosthogonimus*. Jour. Amer. Med. Vet. Ass'n., 70: 620–624.

Krull, Wendel H. 1931.—Life history studies on two frog lung flukes *Pneumonoeces* and *Pneumobites parviplexus*. Trans. Amer. Micro. Soc., 50: 215–277.

1932.—Studies on the life history of *Pneumobites longioplexus* (Stafford). Zool. Anz., 99: 231–239.

1933.—A note on the life history of a trematode, *Eustomos chelydrae* MacCallum, 1921. Jour. Parasit., 20: 326.

1935.—A note on the life cycle of *Telorchis robustus* Goldb. (Trematoda: Telorchiidae). Proc. Helm. Soc. Wash., 2: 65.

La Rue, George R. 1926.—Studies in the trematode family Strigeidae (Holostomidae). No. 3. Relationships. Trans. Amer. Micro. Soc., 45: 265–281.

Looss, A. 1899.—Weitere Beiträge zur Kenntniss der Entwicklung von *Distomum leptosum* Olsson. Zool. Jahr., Abt. syst., 12: 54–184.

Lühe, M. 1909.—Parasitishe Plattwürmer, I: Trematodes de Susswasser Fauna Deutschlands. 17. Jena.

McCoy, Oliver R. 1928.—Life history studies on trematodes from Missouri. Jour. Parasit., 14: 207–228.

McMullen, Donald B. 1934.—The life cycle of the turtle trematode, *Cercorchis medius*. Jour. Parasit., 20: 248–250.

1935 (a).—The life cycle and a discussion of the systematics of the turtle trematode, *Eustomos chelydrae*. Jour. Parasit., 21: 52–53.

1935 (b).—A note on the relationship of the Telorchinae and the Reniferinae. Jour. Parasit., 21: 217–219.

1935 (c).—The life histories and classification of two Allocreadiid-like plagiorchids from fish, *Macroderoides typicus* (Winfield) and *Alloglossidium corti* (Lamont). Jour. Parasit., 21: 369–380.

1936.—A note on the life cycle of *Mosesia chordeilesia* n. sp. (Lecithodendriidae). Jour. Parasit., 22: 295–298.

1937.—The life histories of three trematodes, parasitic in birds and mammals, belonging to the genus *Plagiorchis*. Jour. Parasit., 23.

Macy, Ralph W. 1934.—Studies on the taxonomy, morphology and biology of *Prosthogonimus macrorchis* Macy, a common oviduct fluke of domestic fowls in North America. Univ. Minn. Agri. Exp. Sta. Tech. Bull., 98: 7–71.

Magath, T. B.—1917.—The morphology and life history of a new trematode parasite, *Lissorchis fairporti* nov. gen. et nov. spec., from the Buffalo fish, *Ictiobus*. Jour. Parasit., 4: 58–69.

Mehra, H. R. 1931.—A new genus (*Spinometra*) of the family Lepodermatidae Odhner (Trematoda) from a tortoise, with a systematic discussion of the family. Parasit., 23: 137–178.

Nöller, Wilhelm, and Konrad Ullrich. 1927.—Die Entwicklung einer *Plagiorchis*-Art. Sitzungsberichte der Gesellschoft naturforschender Freunde, 81–86.

Odhner, Th. 1910.—Nordostabikanische Trematoden, grosstenteils vom Weissen Nil. Results of the Swedish Zoological Expedition to Egypt and the White Nile. 1: 1–170. Uppsala.

Pagenstecher, H. A. 1857.—Trematodenlarven und Trematoden: Helminthologishiche Beträge. Heidelberg.

Perkins, M. 1928.—A review of the Telorchinae, a group of distomid trematodes. Parasit., 20: 336–356.

Pratt, H. S. 1902.—Synopsis of North American invertebrates. Amer. Natur., 36: 953–979.

Price, E. W. 1936.—Redescription of the type species of the trematode genera *Lechriorchis* Stafford and *Zeugorchis* Stafford (Plagiorchiidae). Proc. Helm. Soc. Wash., 3: 32–34.

Sewell, Seymour. 1922.—Cercariae Indicae. Ind. Jour. Med. Res., 10: 1–372.

Sinitsin, Th. 1905.—Materiaux pour servir a l'Histoire naturelle des trematodes. Le distomides des batraciens et des poissons des environs de Varsovie. Versovie, 210 p. (Russian).

1907.—Observations sur les metamorphoses des Trematodes. Arch. Zool. Exper. et Gener., 7: 21–37.

Stafford, J. 1905.—Trematodes of Canadian vertebrates. Zool. Anz., 28: 681–694.
Stunkard, Horace W. 1933.—The life cycle of *Plagitura parva*. Jour. Parasit., 20: 135.
Talbot, S. Benton. 1933.—Life history studies on the trematodes of the sub-family Reniferinae. Parasit., 25: 518–545.
1934.—A description of four new trematodes of the sub-family Reniferinae with a discussion of the systematics of the sub-family. Trans. Amer. Micro. Soc., 53: 40–56.
Tanabe, H. 1922.—A contribution to the study of the life cycle of hermaphroditic distomes. A study of a new species, *Lepoderma muris* n. sp. Okayoma Igakkai Zasshi, 47–68. (Japanese).
van Thiel, P. H. 1930.—Die Entwicklung von *Agamodistomum anophelis* zum *Pneumonoeces variegatus* Rub. Centralbl. f. Bakt. Abt., 117: 103–112.
von Linstow, O. 1890.—Ueber den Bau und die Entwicklung des *Distomum cylindraceum* Zed. Archiv. f. Mikr. Anat., 36: 174–191.

TWO NEW DERMACENTORS FROM CENTRAL AMERICA[1]

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Entomologist, United States Public Health Service

Dermacentor dispar n. sp. (Text Figure 1, Plate I, Figures 1, 3, 4 and 6)

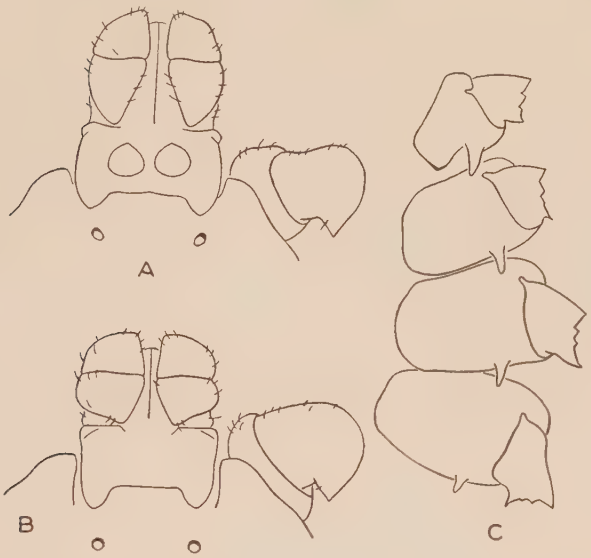


Fig. 1. *Dermacentor dispar* n. sp. A. Capitulum and spur on trochanter of leg I of the female; B. Capitulum and spur on trochanter of leg I of the male; C. Coxae I to IV of the male.

Male

Length from the humeral angles to caudal margin 5.58 mm.; width 3.78 mm.; oval, concave on the dorsal surface. Base color amber-brown with a faint color pattern of tan-gray. (See Pl. I, Figs. 1 and 3).

Basis capituli. About twice as wide as long, convex; cornua well developed, about as wide as long, rounded at the points. Tan-gray color prevailing over dorsal surface and with numerous punctations present.

Palpi. Short, broad and rounded at the ends; tan-gray color present; postero-dorsal angle on article 2 only moderately developed; a few scattered hairs and punctations present.

Scutum. Cervical grooves represented only by deep circular pits in the cervical region; lateral grooves absent, their positions occupied by a lineal series of a few large punctations; scutum bounded at the sides by definite ridges just outside of the lineal series of large punctations, rounded over the top and extending from the vicinity of the eyes to the spiracular plates where they are abruptly terminated in overhanging ends. The punctations are of two kinds, large and small (as in other species of this genus)—large ones few in number, more numerous in the cephalic

[1] Contribution from the Rocky Mountain Laboratory, United States Public Health Service, Hamilton, Montana.

region and small ones numerous and usually easily visible only against the background of the tan-gray.

Festoons. Eleven in number, elevated and, together with the lateral ridges, limiting the concave dorsal surfaces of the scutum. Festoons are arranged in groups of three, two and one, the single one being median. The festoons in these groups are coalesced, each group being separated by a broad, deep groove.

Legs. Robust, smooth, glabrous and with very few short hairs present; spots of tan-gray on the dorsal surface present at the articulations.

Ventral Surface

Ventral surface of body without hairs or spines; with numerous inconspicuous punctations; ventral festoons with short retrograde projections, four in number on each side of the median line.

Basis capituli. Convex and with the posterior edge elevated into a definite salience which extends to and around the postero-lateral corners which are well rounded. Article 1 of the palpus with three palpal setae; 2 with four; 3 with two or three which are smaller.

Coxae. Evenly convex, glabrous and with a very few spines. Coxa I definitely smaller than II, III or IV; IV only slightly larger than III. (In *Dermacentor* coxa IV is usually much the largest, in the male). External spurs present on all four coxae; finger-like in shape, that on I being the longest, those on II, III and IV being successively smaller. Internal spur on coxa I short, broad and with the posterior edge elevated and rounded at the point. No internal spurs present on coxae II, III and IV.

Spiracular plate of both sexes. Comma-shaped with a very broad dorsal horn directed, in the female, about 15° caudad of a 90° line erected from the long axis of the macula and in the male directed about 15° cephalad of the 90° line; goblets very numerous and very small.

Female

(The single fe[illegible] is partly engorged and measurements of length and width would not be reliable for unfed females of the species.)

Basis capituli. About twice as wide as long, more flattened than in the male; porose areas with the longer axes of the two in one line which is at right angles to the median line of the tick; cornua as in the male. The tan-gray of the pattern color prevails on the dorsum of the basis capituli as well as on the palpi; a few punctations present.

Palpi. Longer than in the male, broad, rounded at the ends; postero-dorsal angle on article 2 definite, well elevated; a few scattered punctations and short hairs present.

Scutum. Length 1.56 mm.; width 1.8 mm.; the portion back of the eyes a hemicircle; cervical grooves represented by deep oval pits; the tan-gray prevails on the scutum; large punctations few in number; small punctations numerous; hairs absent.

Post scutal area. Lateral grooves are plainly indicated in the partly fed specimen. *Festoons, 10 in number.* (Festoons present in an even number is unusual and the possibility of this being a teratological specimen should not be overlooked.)

Ventral Surface

Capitulum. Characters on the venter of the female capitulum are essentially the same as in the male excepting that the length is greater.

Coxae. Characters on the coxae of the female are essentially as in the male with the exceptions that the external spur on coxa I is longer and the external spurs on coxae II, III and IV are shorter.

In describing species in this genus, writers for many years have used as characters many points that the various species have in common. The

writer has prepared a diagnosis of the genus *Dermacentor* which will be included in a paper soon to appear. This makes it possible to reduce the length of specific descriptions without omitting necessary points.

Ticks that have been preserved in alcohol are usually changed in their colors. The base color often becomes darker and the lighter pattern color markings are reduced and, in specimens that have only a faint pattern, they may be lost. The male specimen here described was received in alcohol and transferred to a solution containing alcohol, glycerine and acetic acid. This male was left in the open air at room temperature for 1½ hours after treatment with the solution containing acetic acid and the tan-gray came back to a surprising degree. The extent and definiteness of the pattern would not have been suspected if the specimen had not been so treated. Such treatment of valuable specimens is warranted only in specimens preserved with some glycerine present in the fluid.

Described from one male and one female taken from a peccary *Tayassu pecari ringens* (Merriam) at El Paso, Peten, Guatemala, collected by Sam Clark. (No date given.) The specimens here described were received from Dr. Joseph Bequaert of Harvard Medical School.

Dermacentor imitans Warburton ("On Five New Species of Ticks" by Cecil Warburton, Parasitology, Vol. XXIV, No. 4, January, 1933.)

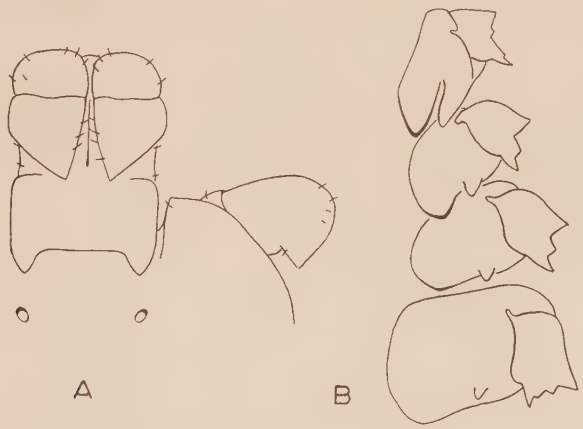


Fig. 2. *Dermacentor latus* n. sp. Male. A. Capitulum and spur of trochanter of leg I; B. Coxae I to IV.

is the most closely related species that is known. A single type specimen of the male of *D. imitans* very kindly loaned by Mr. Warburton has made possible the following comparison. The specimen of *imitans* has the lateral ridges much less elevated, the festoons are in units and not grouped; coxa IV is distinctly larger, and external spurs on coxae II, III and IV are much shorter. The new species is larger than *imitans,* the male specimen here described being 5.58 mm. against 3.0 mm. long in *imitans.*

One male, the holotype, and one female, the allotype, A. P. No. 12000 deposited in the collection of the Rocky Mountain Laboratory, Hamilton, Montana.

Dermacentor latus n. sp. (Text Figure 2, Plate I, Figures 2 and 7)

Male

Oval; length from the humeral angles to the caudal margin 4.75 mm.; width 3.12 mm. Base color dark amber-brown, pattern color gray.

Basis capituli. About twice as broad as long, slightly concave in the median area and with both large and small punctations present. Cornua well developed, triangular, and with ends subacute. Gray color present on both the basis capituli and the palpi.

Palpi. Moderately long, broad, rounded at the ends and with a few scattering hairs and small punctations present; postero-dorsal angle on article 2 well developed and with its elevated diagonal edge pronounced to the lateral margin of the palpus.

Scutum. Cervical grooves present only as deep, oval pits in the cervical region; lateral grooves absent, their positions occupied by a lineal series of moderately large punctations which are not in perfect alignment. Punctations of two sizes present, the large ones being deep and scattered over the dorsum and with some present on the festoons; the small ones numerous, and more easily seen against the background of the gray pattern. (See Pl. I, Fig. 2.) The color pattern consists of continuous lines and stripes which border the amber-brown spots. The limits of the pseudoscutum are indicated by the gray pattern which is present also on the lateral borders of all of the festoons. Festoons, eleven in number, well developed.

Legs. With a few short hairs and small punctations present on the dorsal surfaces; the gray of the pattern color evident (in this alcoholic specimen) only on the distal ends of the femurs and tibias of legs II, III and IV.

Ventral Surface

Basis capituli. Convex, with the posterior margin elevated into a definite edge; a few short hairs and punctations present at the sides. Palpal setae present on articles 1, 2 and 3 and with a few other hairs and punctations present on the ventral surface and at the sides.

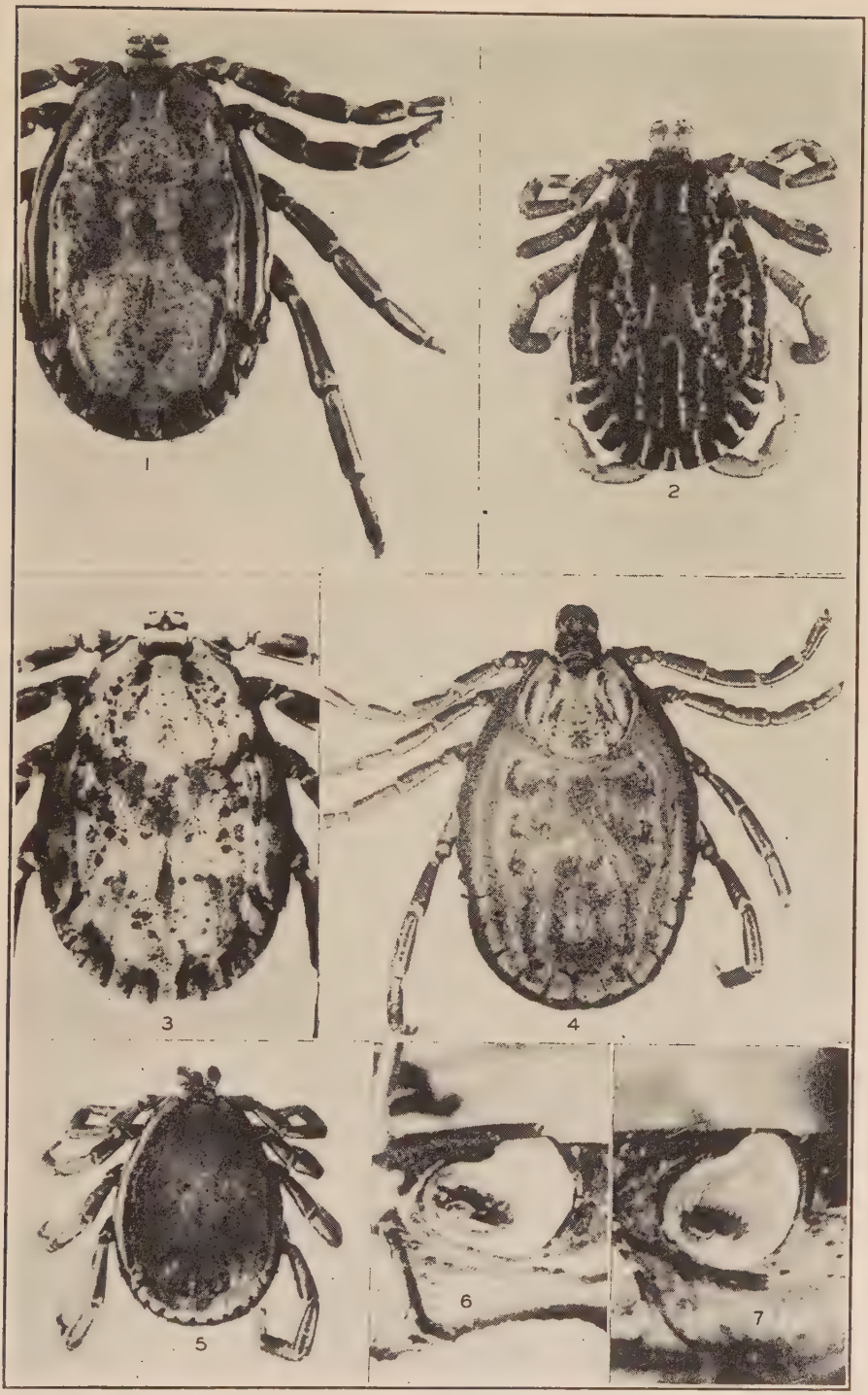
Coxae. All coxae with a very few spines present. Coxa I with both internal and external spurs very well developed, their proximal edges nearly parallel and with the points rounded; the internal spur longer than the external; the external spur slightly curved. External spurs on II, III and IV successively smaller, each one being about as long as its width at the base; internal spurs on II and III, broad, short and rounded; internal spur on IV absent.

Spiracular plate. Comma-shaped with a very broad dorsal horn directed at about 90° from the long axis of the macula; goblets very numerous and very small.

Female unknown.

PLATE I

Fig. 1. *Dermacentor dispar* n. sp. Male.
Fig. 2. *Dermacentor latus* n. sp. Male.
Fig. 3. *Dermacentor dispar* n. sp. The same specimen as in Fig. 1, after being treated to bring out the tan-gray color pattern.
Fig. 4. *Dermacentor dispar* n. sp. Female. (Specimen had fed before being taken from the host.)
Fig. 5. *Dermacentor imitans* Warburton. Male.
Fig. 6. *Dermacentor dispar* n. sp. Spiracular plate of the male. The overhanging end of the lateral ridge is well shown in this photograph.
Fig. 7. *Dermacentor latus* n. sp. Spiracular plate of the male.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Described from one male sent by Professor Manuel Valerio, Director del Museo Nacional, San Jose, Costa Rica, on June 23, 1934. The specimen was taken from a young tapir in the mountains in the Province of Guanacaste, Costa Rica.

Dr. P. Schulze, Rostock, Germany, has very kindly sent me two males and one female of *Dermacentor marginatus* taken near Ueskub (Skopleje) Mazedonian Rind and Hvar (Lesina). The specimen here described as new resembles in some particulars the two males from Dr. Schulze but differs distinctly in some points. The new species, in dorsal view, is much broader at the anterior region than is *D. marginatus*. It differs also in lacking the lateral grooves, in having the palpi shorter, and in having the basis capituli distinctly wider than long, while in *marginatus* the basis capituli is slightly longer than wide. The spiracular plate in the new species is wider than in the male *D. marginatus* and has its dorsal horn less attenuated.

The holotype, A. P. No. 10712, deposited in the collection of the Rocky Mountain Laboratory, Hamilton, Montana.

TWO NEW SPECIES OF STRIGEID CERCARIAE FROM THE DOUGLAS LAKE REGION, MICHIGAN*

W. W. Cort and Sterling Brackett

INTRODUCTION

Studies on the cercariae and life cycles of strigeids have been reported from the University of Michigan Biological Station since 1917 when Cort (1917) described two species of cercariae of this group, *Cercaria douglasi* and *C. emarginatae.* These species were described very briefly and not figured in detail except for the excretory systems. One of them, *C. douglasi,* was redescribed by Cort and Brooks (1928) and was later shown by Van Haitsma (1931 a) to be the cercaria of *Cotylurus flabelliformis* (Faust, 1917). The other, *C. emarginatae,* is now identified as the cercaria of *Cotylurus communis* (Hughes, 1928) (see La Rue, 1932). Van Haitsma (1930) obtained the cercaria of this species by experimental infection of the snail intermediate host. While there are certain discrepancies between the two descriptions, it seems practically certain that they both refer to the same species of cercaria.

Miller (1923 and 1926) described three more species of strigeid cercariae from this region, *Cercaria burti, C. tenuis,* and *C. chrysenterica;* and later Cort and Brooks (1928) added seven more, *C. longifurca, C. flexicauda, C. laruei, C. modicella, C. marcianae, C. bessiae,* and *C. physae. C. flexicauda* has been shown by Van Haitsma (1931 b) to develop into *Diplostomum flexicaudum* (Cort and Brooks, 1928). The recent studies of the Hunters (1933 and 1935) and Krull (1932 and 1934) have shown that *Cercaria bessiae* is the larval stage of *Crassiphialia ambloplites* (Hughes, 1927). Certain information on further development is also known for others of these species of cercariae. *C. burti* closely resembles the cercaria of *Apatamon gracilis* (Rud.), the life cycle of which was worked out by Szidat (1929 and 1931). *C. chrysenterica* penetrates into certain species of fish and appears to become localized in the eye (Cort and Brooks, 1928). *C. laruei* also penetrates into certain species of fish and develops into a diplostomulum in the lens of the eye (Cort and Brooks, 1928). *C. marcianae* was shown by Cort and Brooks (l.c.) to penetrate into tadpoles and develop into *Agamodistomum marcianae* (La Rue, 1917). This species appears to be closely related to *Alaria mustelae* Bosma, 1931, the life history of which was worked out by Bosma (1931 and 1934).

* A contribution from the University of Michigan Biological Station and the Department of Helminthology, School of Hygiene and Public Health, The Johns Hopkins University.

[1] These specific names are arbitrary combinations of letters.

All of the twelve species of strigeid cercariae mentioned above have been collected and identified from the Douglas Lake region since their original descriptions, and most of them are frequently encountered. In addition, several other species which appear to be new have been found. Two of these will be described in detail in the present paper as *Cercaria yogena* n. sp. and *Cercaria dohema* n. sp.[1]

METHODS OF STUDY

The material for the present study was obtained from snail hosts that had been separated into half pint milk bottles and examined for escaping cercariae. Tentative identifications made from observing the cercariae in the water with a hand lens were then checked by microscopical examination. In order to study the behavior of the cercariae while free in the water, they were removed from the original containers and examined under a variety of conditions of light and magnification until an adequate understanding of the peculiarities of their resting position and swimming activities was obtained.

All the morphological observations were made on living material. Both cercariae that had emerged naturally and those that had been dissected from the tissues of the snail were used. The details of morphology were first worked out as far as possible on mounts of living specimens studied with a four mm. objective. These were checked and further details added by use of the oil immersion lens. With strigeid cercariae unstained material was found to be most useful; although the observation of certain points could be made more readily with the use of intra vitam stains. The microscopical studies of living cercariae could best be made on recently emerged specimens at times when the surrounding temperature was rather low. The use of cercariae for study too long after their escape was very confusing on account of degenerative changes. A comparison of naturally emerged cercariae with those dissected from the snails' tissue was often very helpful. For example, in the present studies certain confusing points in the pattern of the excretory system were first cleared up on immature specimens from the snails' tissue; and then checked later on cercariae that had naturally emerged.

A large variety of intra vitam stains were tried. The most useful of these staining methods was the combination of neutral red and Nile blue sulphate used by Talbot (1936) for the study of schistosome cercariae. The cercariae are first stained with very dilute neutral red for a period of from 5 to 10 minutes in a glass finger bowl half full of water. Then, two or three drops of Nile blue sulphate are added. Since the Nile blue sulphate penetrates rapidly, the cercariae are usually ready for study within five minutes. Another staining method used by Dr. Talbot

[1] These specific names are arbitrary combinations of letters.

during the summer of 1936 on schistosome cercariae also proved useful for the strigeids. He found that neutral red following orange G often stained the excretory system and gave good differentiation of the penetration glands. These intra vitam staining methods were less useful for strigeid cercariae than for the schistosomes. Perhaps their greatest value was that the different variations in the intensity of the stains gave varying appearances to certain structures which aided in rechecking former observations.

It is a difficult matter to make measurements that can be used for specific determination for a species of cercaria. The great power of extension and contraction makes measurements taken on living material entirely too variable. For the strigeid cercariae, measurements on heat-killed specimens showed too great variation. After trying several methods of killing, we found that the cercariae fixed in hot formalin gave the most constant results. Although the body is noticeably shortened especially in the preacetabular region, it seemed to us that the degree of this contraction was consistent enough in the material measured so that the measurements could be used for comparison with material similarly handled.

The cercariae on which the measurements were to be made were killed in the following manner. Water containing recently emerged cercariae was placed in a glass finger bowl and an equal amount of boiling 10 per cent formalin was rapidly poured in. The cercariae were then mounted on slides for measurement with a compound microscope. Body and tail dimensions were measured with a 10 ocular and a 16 mm. objective. For the other measurements a 4 mm. objective was used. A certain amount of selection was used since only those which had been killed in a straightened position could be measured accurately. Only a comparatively few of the cercariae, however, were so distorted that they could not be measured. The dimensions given in this paper are obtained from 50 measurements unless otherwise stated. The probable error of the mean and the extremes are both given to indicate the character of the variation. Intra vitam staining of cercariae before killing was used in certain cases since it made the specimens easier to handle and measure, without altering the dimensions. While the method of making measurements given above is far from being ideal, we feel that it makes possible significant comparisons, which are impossible with the measurements usually given in descriptions of cercariae.

The drawings of the cercariae of the two species described in this paper are semi-diagrammatic representations of the interpretations of the different structures from the study of the large series of specimens used. The size relations shown in the drawings of the cercariae are an attempt to approximate those of the living worm and vary somewhat

from the means obtained in the measurements of the mtaerial killed in hot formalin.

To obtain the daughter sporocysts of these species for study, the shell of the infested snail was carefully broken away from the digestive gland, and this structure was teased apart in about 0.1 per cent saline solution. Usually by this method, a number of unbroken sporocysts can be separated out and mounted on slides for study. They were studied and drawn when possible while alive. If they were too active for drawing under the camera lucida, they were killed for measuring and drawing by allowing a little formalin to flow under the cover glass. As far as was observed the killing of the sporocysts, while making them opaque, did not alter their size or shape to any appreciable extent, except in the relations of the anterior tip. Sporocysts in very old infestations are not suitable for study since they have a tendency to become considerably modified in structure.

Cercaria yogena n. sp. (Figs. 1–4)

Specific diagnosis: Strigeid cercaria; rather small form with body shorter than tail stem; furcae almost equal in length to tail stem; when free in water hangs for a considerable part of time with body suspended downward; well developed ventral sucker and pharynx present; intestinal ceca well developed, extending to about two-thirds of distance from the ventral sucker to posterior end; penetration glands four, back of ventral sucker; caudal bodies twelve, somewhat irregular in arrangement; patches of yellow pigment in front of ventral sucker; body spines reaching to posterior end of body, arranged in rows from oral cap of spines to posterior margin of ventral sucker; about 12 forward pointing spines at anterior tip in circumoral spineless area; three to four rows of spines on ventral sucker; excretory system without bladder commissures; six flame cells in body on each side, three connected with anterior collecting tube and three with posterior; two flame cells on each side in tail stem; "island of Cort" large; body branches of bladder ciliated for most of length; daughter sporocysts with anterior tip rather pointed and with prominent protruded birth pore; development in *Stagnicola emarginata angulata* (Sowerby), *S. emarginata canadensis* (Sowerby), and *S. palustris elodes* (Say), in the Douglas Lake region, Michigan, U. S. A.

Distribution. *Cercaria yogena* is widely distributed in the region around the University of Michigan Biological Station. In *S. emarginata angulata* it has been collected from Douglas Lake, Burt Lake, and Mullet Lake. In Crooked Lake, Black Lake, and Pickeral Lake it has been found to occur in *S. emarginata canadensis;* and it has been picked up twice in Douglas Lake in *S. palustris elodes.* Its incidence is usually low and in only three collections did it approach 10 per cent. It is very infre-

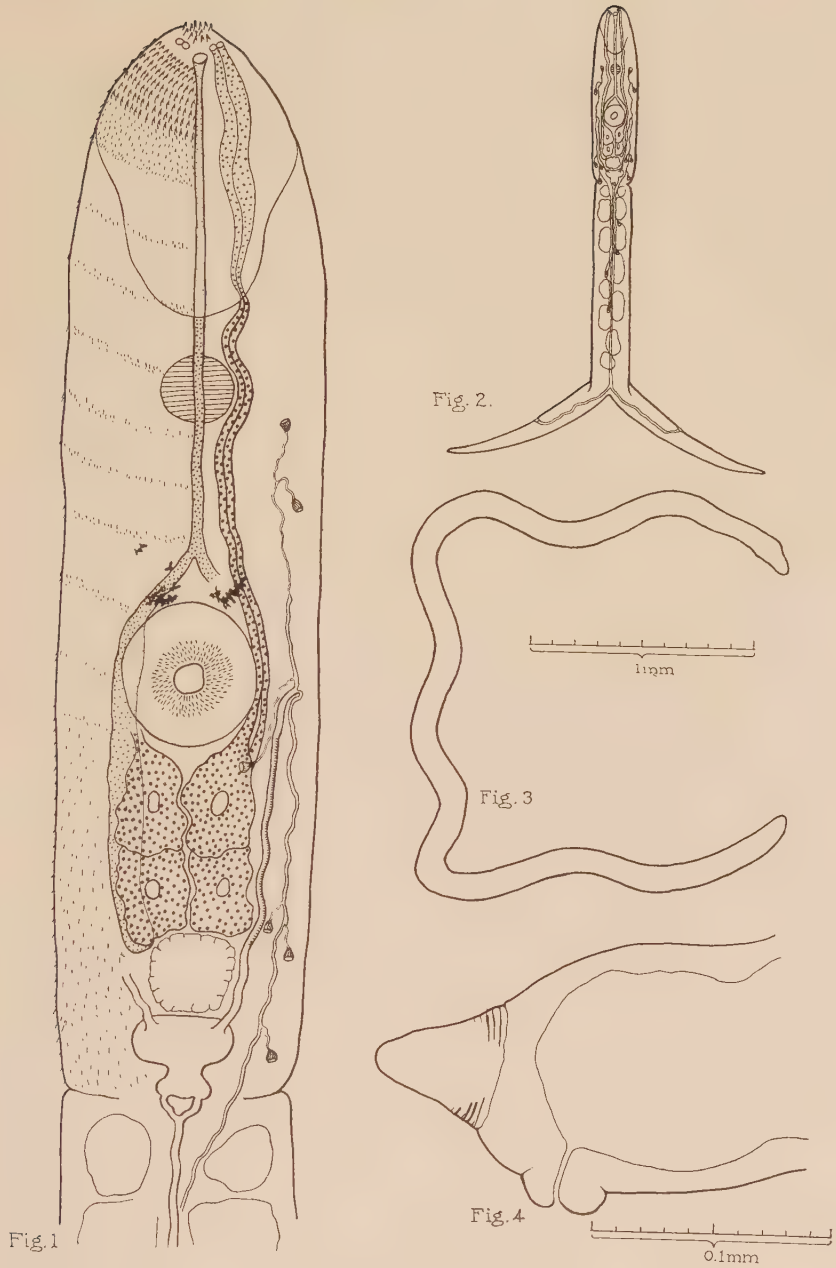

PLATE I

Fig. 1. Semidiagramatic drawing of the body of *C. yogena* showing structural details, ventral view.

Fig. 2. Semidiagramatic drawing of *C. yogena* showing the relations of the body and tail, ventral view.

Fig. 3. Camera lucida drawing of the outline of a daughter sporocyst of *C. yogena.*

Fig. 4. Camera lucida drawing of the anterior end of a daughter sporocyst of *C. yogena.*

quently found before the middle of July, and its incidence appears to increase as the season progresses. Further data on the distribution and occurrence in multiple infestations of *C. yogena* will be published later (Cort, McMullen, and Brackett, 1937).

Behavior. *Cercaria yogena* spends part of its free life hanging suspended in the water. As the cercariae of this species are viewed free in the water at any given moment, about half of them are seen to be swimming and about half floating. There is some tendency for the floating cercariae to assume a vertical position, but when a number are viewed together in the water their long axes are at all angles with the vertical axis of the container. While in the floating position, these cercariae have the preacetabular region of the body bent slightly ventrad. The furcae form almost exactly a right angle with each other so that the angle between them and the tail stem is about 135°. The resting cercariae have a constriction of the body just back of the ventral sucker which can be seen with the low power of the dissecting microscope. When a cercaria starts to swim, it moves rapidly posteriorly in the direction that the tail happened to be pointed; so that at one time in a bottle, cercariae are swimming in all directions even horizontally and downward. They travel quite a distance during each swimming period and change their direction of movement one to several times, often following almost a spiral course before they come to rest again.

Size and shape. *Cercaria yogena* is a comparatively small form for strigeid cercariae. The measurements in micra of fifty specimens killed in hot formalin according to the technique described above show the following relations: body length, 143–193 μ, mean 173 ± 1.3 μ; body width, 36–43 μ, mean 41 ± 0.3 μ; distance from anterior tip to middle of ventral sucker, 72–114 μ, mean 98 ± 1.1 μ; tail stem length, 200–257 μ, mean 236 ± 1.5 μ; tail stem width, 36–43 μ, mean 36 ± 0.1 μ; furcal length, 190–243 μ, mean, 221 ± 0.9 μ. The most characteristic point in the shape of *C. yogena* besides the shortness of the body as compared with the tail stem and furcal length, is the constriction which is present just back of the ventral sucker in living specimens especially when resting free in the water.

Suckers. The oral sucker of *C. yogena* is very large having a length for 50 measurements of 36–56 μ, mean 48 ± 0.5 μ and a width of 19–28 μ, mean 25 ± 0.2 μ. The ventral sucker which is just back of the middle of the body is much smaller, having a diameter for 50 measurements of 21–26 μ, mean 23 ± 0.1 μ.

Pigment. The cercariae of this species are without eyespots but contain yellow pigment granules. These granules are easily seen even with very low powers of the microscope and make identification of this species easy. They are usually in two groups just in front of the ventral sucker

as shown in Figure 1. There is, however, considerable variation in their distribution, since scattered granules may sometimes be seen almost up to the oral sucker and even slightly back of the ventral sucker. A few scattered granules of the pigment are also present in the tail stem.

Spination. At the anterior tip dorsal to the mouth in *C. yogena,* there is a group of about 12 forward pointing spines. Between these and the characteristic oral cap of hooked spines is the circumoral spineless area in which the mouth and the ducts of the penetration glands open. In living specimens the anterior tip of the worm is constantly pushed out and drawn in, which would give both the clump of forward pointing spines and those of the oral cap a chance to function in penetration. The relations of the anterior tip and the arrangement of spines on the ventral surface of the body are shown in Figure 1. There are about seven rows of spines in the oral cap, which extends back only about one third of the length of the oral sucker. The spines of the body just back of the oral cap are somewhat different in arrangement on the dorsal as compared with the ventral surface, since there is a narrow spineless zone followed by a band which contains three somewhat irregular rows. On this same area of the ventral surface (see Fig. 1) the spines of these three rows form a band starting immediately back of the oral cap. Back of this, nine rows of very fine spines could be seen on both the dorsal and ventral surfaces completely encircling the body, the last row being at about the level of the posterior margin of the ventral sucker. On the dorsal surface, the spines are fewer in the rows, and the postacetabular region back of this last row is spineless. On the ventral surface, bands of scattered spines on each side extend to the posterior end not, however, reaching into the mid-ventral zone. There is also a band of heavier spines irregularly arranged in approximately three rows around the opening of the ventral sucker. No spines could be made out on the tail.

Digestive tract. The buccal cavity is represented by a narrow tube leading from the slightly ventral mouth through the oral sucker. There is a distinct prepharynx about 7 to 8 μ in length and a well developed pharynx, which had a diameter in 29 measurements of 7–12 μ, mean 10 ± 0.2 μ. The esophagus continues posteriorly as a narrow tube which bifurcates just in front of the ventral sucker. The intestinal ceca are considerably wider and extend back to about two-thirds of the distance from the posterior margin of the ventral sucker to the posterior end of the body.

Penetration glands. The penetration glands are four in number back of the ventral sucker and are quite large in size, containing large dark granules which show especially clearly when the cercariae are stained with Nile blue sulphate. These glands are ventral to the intestinal ceca and do not extend laterally beyond them. The ducts lead forward in

groups of two on each side, pass into the oral sucker where they are broader, and open on each side and slightly dorsal of the mouth (Fig. 1).

Genital primordium. The genital primordium is comparatively quite large and fills the space between the bladder and the posterior limits of the penetration glands. It is about the size of the fully distended bladder.

Excretory system. The excretory bladder when fully distended is "mushroom" shaped. There is an unusually large "island of Cort," and the caudal tube from the bladder offers nothing characteristic since it runs down the center of the tail stem, divides to pass into the furcae, and the divisions open on the dorsal edges of the furcae at about the midpoints of their length. The tubular extensions of the bladder in the body open into it at the anterior corners slightly ventrad and pass forward on each side without convolutions to receive the anterior and posterior collecting tubes at the level of the middle of the ventral sucker. These tubes are ciliated for most of their length (Fig. 1), a characteristic which we have not seen in any of the other strigeid cercariae studied. There are on each side in the body three flame cells connecting with the anterior and three with the posterior collecting tube. The four flame cells in the tail stem are quite scattered, those on the left side being further forward. The position of the flame cells of the body and tail is shown in Figures 1 and 2.

Tail structures. The tail stem is almost as wide as the body and the circular muscles are well developed. There are twelve caudal bodies in the tail stem (Fig. 2), which are arranged irregularly in six pairs. The first pair is smaller and the last three pairs are usually not of uniform size or arrangement. The superficial bands of nuclei in the tail stem were not worked out in detail. Fine hair-like projections are present on the tail stem as in other strigeid cercariae, but their arrangement was not worked out. The furcae are similar to those of other species of strigeid cercariae.

Daughter sporocysts. The daughter sporocysts (Fig. 3) of *C. yogena* are, as in other strigeid cercariae elongate whitish sacs. They are usually embedded in the digestive gland of the snail host; but in some cases they are present around the stomach, intestine, and reproductive organs. It was possible by careful manipulation to free whole sporocysts from the snail tissues. Sporocysts containing fully developed cercariae vary considerably in length. The longest measured had a length of 6.8 mm. The width of the sporocyst is quite uniform with no noticeable constrictions, varying from 100 to 150 μ. This width of course appears greater in a specimen flattened under a cover glass. The walls of the sporocysts are thin and contain scattered dark pigment. The body cavity extends from the posterior end of the sporocyst up to the birth pore. Its width is uniform, and as many as 6 to 8 well developed cer-

cariae will be seen lying side by side. This is especially noticeable at the anterior end where these cercariae are trying to escape. In front of the birth pore, which is about 85 μ from the anterior tip, the anterior end of the sporocyst tapers abruptly to form a mobile protrusible tip about 50 μ in length. This tip is separated by a slight ridge and shows faint striations in front of this ridge. In living specimens this tip is quite pointed, but in killed specimens it is more rounded. The birth pore is marked by a distinctly protruded area and, since the body cavity extends so far forward, the birth canal is comparatively short. The characters of the anterior end of a daughter sporocyst are shown in Figure 4. In comparing the daughter sporocysts of *C. yogena* with those of other strigeids the following points would seem to be most characteristic, viz., (1) the uniform width and absence of constrictions, (2) the extension of the body cavity up to the level of the birth pore, which makes the birth canal very short, (3) the comparatively large size of the body cavity, which allows 6–8 cercariae to lie side by side, (4) the mobile narrow pointed anterior tip, and (5) and prominence of the area around the birth pore.

Further deevlopment. Unpublished preliminary experiments performed by Miss Ruby Wortham and one of us (W. W. C.) indicate that the second intermediate hosts of *C. yogena* are fish, since the cercariae of this species penetrated into perch and sunfish. Whether they can develop to the metacercaria stage in either of these fish has not been determined.

Comparison with other strigeid cercariae. In checking the literature to determine whether *C. yogena* had been previously described, it was, of course, necessary to compare it only with those strigeid cercariae with four penetration glands back of the ventral sucker. The descriptions of thirteen different species of cercariae were found with this character. Next, all those could be ruled out which had more than twelve caudal bodies in the tail stem. This eliminated cercariae with numerous caudal bodies like those of the cercaria of *Diplostomum flexicaudum* (see Cort and Brooks, 1928) and *C. longifurca* Cort and Brooks, which has 16 such bodies with an entirely different arrangement. Also, in *C. chrysenterica* Miller, 1923, the caudal bodies are quite different. This left the following six species of strigeid cercariae which most closely resemble *C. yogena,* viz., *C. laruei* Cort and Brooks, 1928; *C. modicella* Cort and Brooks, 1928; *Cercaria* sp., Hesse, 1928; *C. micromorpha* Brown, 1926; *C. furcicauda* Faust, 1919, and *C. chromatophora* Brown, 1931. These cercariae differ from *C. yogena* in various characters which need not be elaborated here; since none of them except *C. chromatophora* show the yellow pigment which is the most characteristic single feature of *C. yogena.* The distribution of this yellow pigment in Brown's species appears to agree exactly with that in *C. yogena.* A study of Brown's

(1931) description of *C. chromatophora* shows, however, that it differs from *C. yogena* in several characters. In the first place, *C. chromatophora* is much larger having a body length of 0.27 mm. and a body width of 0.05 mm. Also, the spination extends only to the anterior margin of the ventral sucker; and the number of flame cells in the body and the arrangement of the penetration glands are different.

Cercaria dohema n. sp. (Figs. 5–8)

Specific diagnosis: Strigeid cercaria; small form with body in living specimens about equal in length and width to the tail stem; furcae longer than tail stem; swims constantly when free in the water; well developed ventral sucker and pharynx present; intestinal ceca only slightly developed, being represented by heart-shaped structure in anterior part of body; penetration glands six, small, in two groups of three back of ventral sucker; caudal bodies very large with six pairs in tail stem and one at the base of each furca; body spines limited to pre-pharyngeal region; about 12 forward pointing spines on anterior tip; excretory system with bladder commissure back of ventral sucker, four flame cells on each side in body and only one pair in anterior part of tail stem; two large bodies of unknown relationship in front of ventral sucker; daughter sporocysts with rather blunt anterior tip and only slightly protruding birth pore; in *Stagnicola emarginata angulata* (Sowerby), *S. emarginata canadensis* (Sowerby) *Lymnaea stagnalis appressa* Say, and *L. stagnalis perampla* Walker, in the Douglas Lake region, Michigan, U. S. A.

Distribution. *Cercaria dohema* is widely distributed in the region around the University of Michigan Biological Station. In *S. emarginata angulata* it has been collected from Douglas Lake, Burt Lake, and Mullet Lake. It has also been found in *S. emarginata canadensis* from Crooked Lake, Pickeral Lake, and Black Lake. It is very rare in the varieties of *L. stagnalis,* having been found once in *L. stagnalis appressa* from Douglas Lake and once in *L. stagnalis perampla* from Black Lake. Only in one location, a beach on Burt Lake near the mouth of Maple River, has it ever been found to occur at all commonly. Here it was found in nine collections of *S. emarginata angulata* made in the summers of 1935 and 1936 with an incidence varying from less than 1 per cent to almost 5 per cent. The largest number of snails ever found positive for this cercaria in any one collection was 23 out of a collection of 462 from this locality. Further data on the distribution and occurrence of this species in multiple infestations will be published later (Cort, McMullen and Brackett, 1937).

Activity. The cercariae of this species emerge from the snail host sometime during the night, probably in the early morning; although a few keep escaping during the day. They swim constantly in the water, mov-

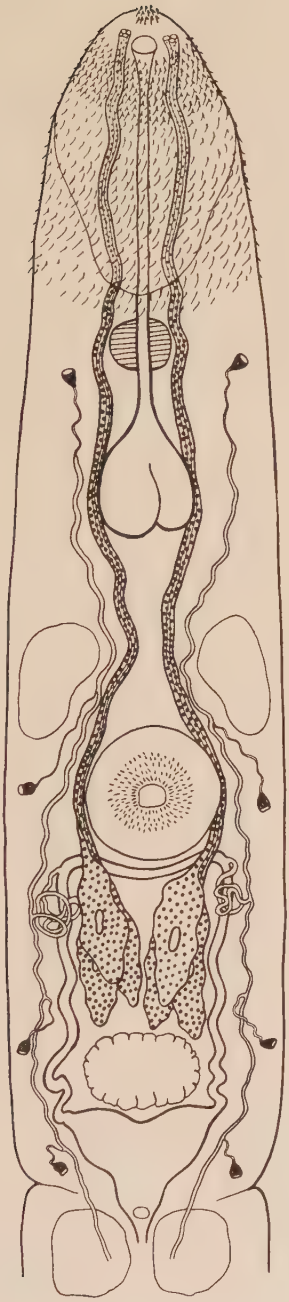

Fig. 5.

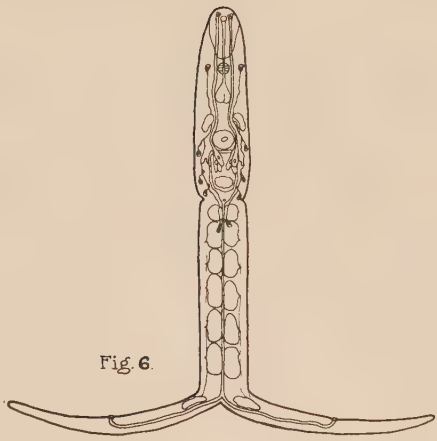

Fig. 6.

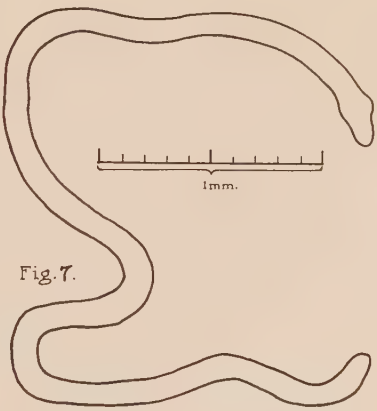

Fig. 7.

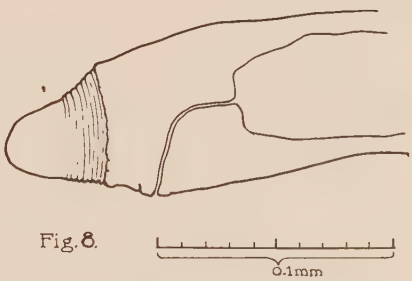

Fig. 8.

PLATE II

Fig. 5. Semidiagramatic drawing of the body of *C. dohema* showing structural details, ventral view.

Fig. 6. Semidiagramatic drawing of *C. dohema* showing the relations of the body and tail, ventral view.

Fig. 7. Camera lucida drawing of the outline of a daughter sporocyst of *C. dohema.*

Fig. 8. Camera lucida drawing of the anterior end of a daughter sporocyst of *C. dohema.*

ing in all directions and changing their direction very frequently. Very seldom are recently emerged cercariae ever seen hanging suspended in the water. They show some tendency to collect toward the top of the water in a bottle, but some will always be found at all levels.

Size and shape. The shape of these cercariae is characteristic in that the body and tail stem in living specimens have practically the same length and width. In measurements of 50 specimens killed in hot formalin the body had a length of 129–200 μ, mean 156 ± 1.7 μ and a width of 33–50 μ, mean 41 ± 0.4 μ. The distance from the anterior tip to the middle of the ventral sucker was 71–129 μ, mean 96 ± 1.4 μ. The tail stem in this series of measurements was slightly longer, 164–200 μ, mean 179 ± 0.8 μ, and had the same width as the body, 36–46 μ, mean 41 ± 0.2 μ. The furcae were slightly longer than the tatil stem, 172–215 μ, mean 196 ± 1.1 μ.

Suckers. The oral sucker in a series of 48 measurements had a length of 31–50 μ, mean 40 ± 0.5 μ and a width of 28–33 μ, mean 29 ± 0.2 μ. The ventral sucker which is back of the middle of the body is much smaller with a diameter in a series of 50 measurements of 17–25 μ, mean 20 ± 0.1 μ.

Preacetabular bodies. One of the most striking structural features of *C. dohema* is the presence of two large conspicuous bodies on each side just in front of the ventral sucker (Figs. 5 and 6). No internal details of structure could be made out in them. Except for their greater size and irregular shape, they resemble the so-called "unpigmented eye-spots" which have been described for certain other strigeid cercariae (see Cort and Brooks, 1928). No suggestions can be made in regard to the function or relationship of these preacetabular bodies.

Spination. The spination in *C. dohema* is very limited (Fig. 5). There is a clump of about 12 forward-pointing spines on the anterior tip just dorsad to the mouth. Back of the circumoral spineless region, there are six or seven irregular rows of large hooked spines forming the oral cap. Back of these, the smaller body spines, which are not arranged in rows, extend to about the level of the pharynx. The opening of the ventral sucker is surrounded by about 4 irregular rows of spines.

Digestive tract. The mouth is slightly ventrad, and the buccal cavity is represented by a narrow tube running through the oral sucker. The prepharynx is short and the pharynx in a series of 39 measurements had a diameter of 7–10 μ, mean 9 ± 0.1 μ. The esophagus is only slightly longer than the prepharynx, and the intestinal ceca are only slightly developed, extending only about halfway from the posterior margin of the oral sucker to the anterior margin of the ventral sucker. They form a heart-shaped structure (Figs. 5 and 6), which is very prominent even under the low powers of the microscope.

Penetration glands. There are six penetration glands in two distinctly separated groups of three each, back of the ventral sucker (Fig. 5). The individual glands are distinctly smaller than is usual for these glands in strigeid cercariae. They are pointed posteriorly and are very granular. Their ducts proceed almost straight forward in two compact groups to pass through the oral sucker and open on each side of the mouth. How different in shape and arrangement the penetration glands of this species are from those of most strigeid cercariae can be readily seen by comparing them with the drawings of these glands for *C. yogena* (cf. Figs. 1 and 5).

Genital primordium. The genital primordium is represented by a mass just in front of the bladder. The outlines of individual cells could not be clearly made out.

Excretory system. The shape of the excretory bladder when distended is shown in Figure 5. It differs definitely in shape from the bladder of *C. yogena,* and the body branches pass directly from its corners. The island of Cort is small, and the tail branch shows the same relations as in *C. yogena* and other strigeid cercariae. The body branches of the bladder pass forward from each corner almost to the level of the ventral sucker and unite in a postacetabular commissure. A common collecting tube enters on each side just before the beginning of the commissure. These tubes are convoluted and receive the anterior and posterior collecting tubes at a level slightly posterior to their point of entrance into the bladder branches. There are two flame cells on each side connected with the anterior collecting tubes and two on each side in the body and one in the anterior part of the tail connecting with the posterior collecting tubes. The characteristics of the excretory system of this species are shown in Figures 5 and 6.

Tail structures. The tail stem has the same width as the body and contains six pairs of large caudal bodies, the first pair being considerably smaller than the others (Fig. 6). They are clearly seen in freshly emerged cercariae but soon tend to break down as the cercariae become older. Two more caudal bodies are present one at the base of each furca. Fine hair-like projections are also present on the tail stem. The furcae are slightly longer than the tail stem, and whenever a cercaria is not swimming, they are held at right angles to it.

Daughter sporocysts. The daughter sporocysts (Fig. 7) of *C. dohema* are long slender whitish sacs usually imbedded in the digestive gland of the snail but sometimes found in the tissues and spaces around the stomach, intestine, and reproductive organs. They vary considerably in length, the longest one measured being 5 mm. They are much narrower than the sporocysts of *C. yogena,* being about 60 μ in diameter. This makes the lumen much narrower than in that species, and usually

not more than two cercariae can be seen lying side by side. The anterior tip in front of the birth pore tapers gradually, is mobile and blunt. There is a distinct ridge a short distance in front of the birth pore. This separates off rather distinctly the mobile anterior tip, which shows distinct striations near its base. In well extended sporocysts, the birth pore is from 60 to 70 μ from the anterior tip. The area around the birth pore projects only slightly and is much less prominent than in *C. yogena.* The walls of the sporocysts are thin and contain a considerable amount of yellow pigment. The body cavity stops a considerable distance back of the birth pore so that the birth canal is quite long. The characters of the anterior end of the daughter spoorcyst of this species are shown in Figure 8.

A comparison of the daughter sporocysts of *C. dohema* with those of *C. yogena* shows a number of very definite differences. In the first place, the sporocysts of *C. dohema* are distinctly narrower than those of the other species, which makes a very distinct difference in the number of cercariae that can lie side by side at any point in the body cavity. Differences in the anterior end are very striking in the shape of the tip, the prominence of the birth pore, the length of the birth canal, etc. (cf. Figs. 4 and 8). The very distinct differences between the daughter sporocysts of these two species indicates that detailed descriptions of these stages are of importance in the descriptions of strigeid cercariae.

Further development. A preliminary experiment by Miss Ruby Wortham and one of us (W. W. C.) showed that *C. dohema* penetrated actively into a species of minnow (Fundulus sp.). Metacercariae that were thought to have come from these cercariae were found in the liver one month later. Since these minnows were also infected with other species of strigeid metacercariae, the determination could not be made with certainty, so that an elucidation of this phase of the life history will have to await further investigations.

Comparison with other strigeid cercariae. Cercaria dohema shows a combination of characteristics which make it easy to identify and to compare with other speries of strigeid cercariae. The most prominent of these characters are the short wide intestinal ceca, the large preacetabular bodies, the number, shape and position of the penetration glands, the limited spination, and the bladder commissure back of the ventral sucker. In our careful survey of the literature of strigeid cercariae we found none which resemble *C. dohema.*

SUMMARY

Two new species of strigeid cercariae, *C. yogena* and *C. dohema,* are described from the Douglas Lake region, Michigan. A detailed account of the methods of study are given. A careful study of the daughter

sporocysts of these species show distinct specific differences. Both species penetrate into certain species of fish, although the development of their metacercaria stages was not traced.

Literature Cited

Bosma, Nelly J. 1931.—*Alaria mustelae* sp. nov., a trematode requiring four hosts. Science, 74 (1925) : 521–522.

1934.—The life history of the trematode *Alaria mustelae* Bosma, 1931. Trans. Amer. Mic. Soc., 53: 116–153.

Brown, F. J. 1926.—Some British freshwater larval trematodes with contributions to their life histories. Parasit., 18: 21–34.

1931.—Some fresh-water larval trematodes from Cheshire. Parasit., 23: 88–93.

Cort, W. W. 1917.—Homologies of the excretory system of the forked-tailed cercariae. Jour. Parasit., 4: 49–57.

Cort, W. W., and S. T. Brooks. 1928.—Studies on the holostome cercariae from Douglas Lake, Michigan. Trans. Amer. Mic. Soc., 47: 179–221.

Cort, W. W., D. B. McMullen, and Sterling Brackett. 1937.—Ecological studies on the cercariae in *Stagnicola emarginata angulata* (Sowerby) in the Douglas Lake region, Michigan. Jour. Parasit. (In press.)

Faust, E. C. 1917.—Life history studies on Montana trematodes. Ill. Biol. Mono., 4(1) : 1–120.

1919.—The excretory sytema in digenea. II. Observations on the excretory system in distome cercariae. Biol. Bull., 36: 332–339.

Hesse, A. J. 1923.—A description of two cercariae found in *Lymnaea peregra* in Scotland. Jour. Helm., 1 : 227–236.

Hughes, R. C. 1927.—Studies on the trematode family Strigeidae (Holostomidae). No. VI. A new metacercaria, *Neascus ambloplites* sp. nov., representing a new larval group. Trans. Amer. Micro. Soc., 46: 248–267.

1928.—Studies on the trematode family Strigeidae (Holostomidae). No. XIII. Three species of tetracotyle. Trans. Amer. Micro. Soc., 47: 414–433.

Hunter, G. W., III. 1933.—The strigeid trematode, *Crassiphiala ambloplites* (Hughes, 1927). Parasit., 25: 510–517.

Hunter, G. W., III, and Wanda S. Hunter. 1935.—Further studies on fish and bird parasites. Suppl. 24th Ann. Rep., N. W. State Conserv. Dept., No. IX. Rep. Biol. Sur. Mohawk-Hudson Watershed, pp. 267–283.

Krull, W. H. 1932.—Studies on the development of *Cercaria bessiae* Cort and Brooks, 1928. Jour. Parasit., 19: 165.

1934.—*Cercaria bessiae* Cort and Brooks, 1928, an injurious parasite of fish. Copeia, 1934: 69–73.

La Rue, G. R. 1917.—Two new larval trematodes from *Thamnophis marciana* and *Thamnophis eques*. Oc. Pap. Mus. Zool., Univ. Mich., No. 35: 1–12.

1932.—Morphology of *Cotylurus communis* Hughes (Trematoda: Strigeidae). Trans. Amer. Mic. Soc., 51: 28–47.

Miller, H. M., Jr. 1923.—Notes on some furcocercous larval trematodes. Jour. Parasit., 10: 35–46.

1926.—Comparative studies on furcocercous cercariae. Ill. Biol. Mono., 10(3) : 1–112.

Szidat, L. 1929.—Beiträge zur Entwicklungsgeschichte der Holostomiden. III. Über zwei Tetracotylen aus Hirudineen und ihre Weiterentwicklung in Enten zu *Cotylurus cornutus* Rud. un *Apatemon gracilis* Rud. Zool. Anz., 86: 133–149.

1931.—Beiträge zur Entwicklungschichte der Holostomiden. IV. Die Cercariae des Entenparasiten *Apatemon* (*Strigea*) *gracilis* Rud. und ihre Entwicklung im Blutefäszsystem des Zwischenwirtes (*Herpobdella atomaria* Car.). Zeitschr. f. Parasitenk., 3: 160–172.

Talbot, S. Benton. 1936.—Studies on schistosome dermatitis. II. Morphological and life history studies on three dermatitis-producing schistosome cercariae, *C. elvae* Miller, 1923, *C. stagniolae* n. sp., and *C. physellae* n. sp. Amer. Jour. Hyg., 23: 372–384.

Van Haitsma, J. P. 1930. Studies on the trematode family Strigeidae (Holostomidae). XXI. Life cycle and description of the cercaria of *Cotylurus michiganensis* (La Rue). Jour. Parasit., 16: 224–230.

1931a.—Studies on the trematode family Strigeidae (Holostomidae). No. XXII. *Cotylurus flabelliformis* (Faust) and its life history. Pap. Mich. Acad. Sc. Arts and Let., 13: 447–482.

1931b.—Studies on the trematode family Strigeidae (Holostomidae). No. XXIII. *Diplostomum flexicaudum* (Cort and Brooks) and stages in its life history. Pap. Mich. Acad. Sci., Arts and Let., 13: 483–516.

NOTES ON *MICROCOTYLE SEBASTIS* GOTO FROM PUGET SOUND*

KELSHAW BONHAM AND JOHN E. GUBERLET

Of fifty or more specimens of each of the two species of rock cod, *Sebastodes maliger* (Jordan & Gilbert) and *S. caurinus* (Richardson), which have been examined, 90% were found to be infested with *Microcotyle sebastis* Goto in numbers ranging up to 115, with a mode at 3–4. These two hosts were about equally infested, while of twenty specimens of the black bass, *Sebastodes melanops* (Girard), about one-fourth harbored one to four worms each.

No members of the genus *Microcotyle* have previously been recorded from Puget Sound, or, in fact, from the American side of the Pacific Ocean.

This series of specimens inhabits a host, *Sebastodes,* closely related to that, *Sebastes,* of the holotype in Japanese waters. Yamaguti has found members of the genus *Microcotyle* on the Japanese *Sebastodes schlegeli,* and has allocated them, with some misgivings, to *Microcotyle sebastis* Goto, saying that the framework of the posterior sucker differs from Goto's representation, and that his specimens show indications of lateral branches from the oesophagus, not mentioned by Goto. Puget Sound forms are intermediate in both characters, as is shown below.

Relaxation of specimens was accomplished with menthol and chloral hydrate according to Galigher, or with fresh water. Some were killed quickly in the extended condition without relaxation, by the use of hot Bouin's solution. Best results in staining whole mounts were obtained with alum cochineal, and for sections Galigher's standard alum hematoxylin and eosin worked admirably.

Ten mature specimens selected at random were used for the measurements given here. The average is followed by the extremes in parentheses. Total length 3.9 (3.1–4.6) mm. The samples did not happen to include the largest specimen at hand which measures 5.8 mm. long by 1.1 mm. wide. It is one millimeter longer than the next longest specimen and possesses 31 pairs of posterior suckers. Width at level of ovary 0.86 (0.64–1.05) mm. Length of posterior haptor 1.3 (0.95–1.7) mm. Distance from genitoatrial opening to anterior tip of body 0.37 (0.28–0.47) mm. Distance from vaginal pore to anterior tip of body 0.64 (0.38–0.86) mm. Proportion of body length occupied by testes 24% (18%–29%). Diameter of oral or anterior sucker perpendicular

* Contribution from Zoological and Oceanographical Laboratories of the University of Washington. This is the sixth of a series of publications on the parasites of Puget Sound fishes by John E. Guberlet and his students.

to septum 88 (60–100) micra. Diameter of oral sucker in line of septum 76 (54–95) micra. Diameter of pharynx 70 (52–81) micra. Number of pairs of posterior suckers 30 (23–31). Width of largest sucker skeleton 104 (88–117) micra. Number of testes 32 (21–48).

To Goto's accurate description of the integument and body musculature, it may be added that in the region of the vaginal opening the integument is thrown into rugged transverse folds (fig. 3), and the prominent muscle layer immediately underneath, disappears and falls short of reaching the vaginal pore.

The organs of attachment are the anterior "sticky glands," so-called by Goto, the anterior suckers, and the posterior sucker-bearing appendage. Price (1934) coins the work *haptor* for the adhesive organs of monogenetic trematodes. Thus, the anterior "sticky glands" are *anterior haptors,* the oral or anterior suckers retain their explicit name, *sucker,* and the posterior sucker-bearing appendage becomes *posterior haptor.* Living specimens can attach to a slide by means of the oral suckers, but no adhesive function was observed for the "sticky glands." The bag-like oral suckers communicate ventrally with the mouth cavity, but are closed off medially (fig. 3) from the part of the digestive tube preceding the pharynx, called prepharynx, by their own median walls.

The posterior haptor is equipped with thirty pairs of clasping suckers arranged in two rows ventrally along either edge. Each sucker is a wide bag with its greatest dimension in the transverse direction of the body. Its base is dorsal. Ventrally it opens by way of a transverse slit. It can be extended, and then quickly closed and withdrawn.

Supporting tissue in the posterior sucker is of two kinds, a prismatic portion (figs. 7–8, p) consisting of parallel fibers perpendicular to the wall of the sucker, and a more highly refractive portion which is in the form of a framework or skeleton. However, the skeleton is seen in sections to be merely the condensation, in places, of a continuous coating of refractive material entirely enveloping the prismatic portion. The prominent parts which appear in whole mounts to be separate elements of the skeleton are thus continuous with one another. But, for convenience, each element is designated by a letter (fig. 6). Antero-lateral pieces (a) are continued baso-mediad over onto the front or inside face of the posterior wall as prong-like projections (b), which are thus only a part of "a". The postero-lateral pieces (c) appear to be distinct from the rest. Their basal ends touch the posterior faces of "b".

The large median element (figs. 6, 7, 9) is J-shaped. Its long leg is in the anterior wall, and its short leg, terminated by the piece "m," is in the posterior wall of the sucker. "J" is partly hollow, with small openings from the lumen to the outside edge. Distally on the short leg, at the inner face of the posterior wall, "J" is prolonged into a thin piece

(m) which Goto has designated as a median "dagger-shaped" piece, hollow in his specimens. In the present forms "m" is not hollow, but is faint and inconspicuous as compared to Goto's representation. Yamaguti says that his own specimens lack "m". The longer, anterior leg of "J" is round in section, but flattens near the tip, and bifurcates, spreading like two wings over the inner face of that wall. The shorter, posterior leg likewise bifurcates and thins out over the outer face of the posterior wall near the junction with "m" which lies on the inner face of the same wall. Only one large muscle (fig. 7, sm) activates each sucker. It originates in, and is continuous with, the longitudinal body musculature. It passes postero-ventrally around the base of the sucker, between the flared tips of the short leg of "J", and is inserted as a tendon between two prismatic portions at the posterior face of "m".

Sagittal sections (fig. 8) show that "a" and "c" form knife-like biting edges at the opening of the sucker.

The digestive tract consists of mouth, prepharynx, pharynx, oesophagus, and two digestive caeca. The mouth, seen from the ventral surface, is a semicircular opening, straight anteriorly, and curved posteriorly. It communicates with the oral suckers dorsally and with the prepharynx ventro-medially. The upper lip is shaded in fig. 3, the lower lip is not. The prepharynx curves dorsally to broaden into a wide, shallow cavity at the anterior end of the pharynx. In many specimens the tissue separating the prepharynx from the antero-ventral extremity of the oesophagus is so indistinct that there appears to be a minute passage there, ventral to the pharynx. In others, this wall is intact, although thin, as in fig. 3. The posterior opening to the pharynx is usually overhung by a flap of tissue.

The large oesophageal cavity ventral to the brain may be flattened by either depression or contraction of that region, to the extent that it then appears to have lateral outpocketings (fig. 11). When the animal is either relaxed or extended these lateral expansions are usually not present.

At a level just behind the genital atrium the digestive tract bifurcates and passes posteriorly as two crura or caeca, to the attachment of the posterior haptor. There the right crus stops, but the left one continues a short distance farther, into the haptor. In no specimen, sectioned or whole, could a posterior fusion of the two crura be observed. Animals recently removed from the host may vomit ingested red blood cells into the water. During egg-making activities, yolk from the genito-intestinal canal has been seen to be forced forward in one intestinal caecum, past the oesophagus, and into the other caecum. Enough yolk may be present to fill both caeca back as far as the ovary. This yolk, when the animals are left for two days in a dish of sea water, is replaced by a mass of black granules which are free to move in the intestine.

Excretory canals (figs. 11, 12) can always be traced in sectioned material, but in life they are conspicuous only where the vitellaria do not obscure them. No flame cells have been recorded for this worm, and here none could be seen in living or preserved material. The canal of either side starts as a fine descending tubule (fig. 11, X) near the brain, and courses backward passing ventral to the intestinal caeca and dorsal to the ventral nerve trunk, as far as the level of the fourth or fifth from the last caudal sucker (fig. 12) receiving small tributaries on the way. At this level it receives a branch from the tip of the posterior haptor, and simultaneously bends back upon itself to pass forward beside its descending limb as an ascending canal of larger diameter, to the excretory pore which is located dorso-laterally at the level of the bifurcation of the digestive tract.

The brain (fig. 13, Br) lies arched like an inverted "U" over the oesophagus. From its lower ends arise the ventral nerve cords (VN) extending to the end of the posterior haptor. Commissures connect these at slightly irregular intervals, and other smaller branches start toward the opposite trunk, but do not form commissures. Dorsal and lateral to the ventral trunks are the lateral nerve trunks (LN) which extend backward approximately to the level of the attachment of the posterior haptor with the body. Strands connect the lateral and ventral trunks, although some appear to be incomplete. Antero-ventral nerves supplying the ventral and lateral walls of the oral suckers originate at the junction of the lateral nerves with the brain. Near the top of the brain is a pair of antero-dorsal nerves supplying the snout and dorsal walls of the suckers.

Testicular lobules (fig. 1, Tes) averaging 30 in number, are connected to the vas deferens by fine vasa efferentia visible only in living specimens. These small ducts run from the median ventral edge of the lobule antero-medially to join the vas deferens. The latter goes forward to the genital atrium, swelling anteriorly into a seminal vesicle and terminating in a penis. Prostate cells, so-called by analogy (Goto 1895) with similarly situated cells in *Hexacotyle,* lie at the sides of the vas deferens from the ovary almost to the genital atrium. No efferent ducts from these cells were seen. From the seminal vesicle the ejaculatory duct passes antero-ventrally to the chamber where the penis is located in the posterior wall of the genital atrium. Four to six stubby spines about 6 micra long lie on either side of the base of the penis within the antechamber.

There are 150–200 spines lining the genital atrium. They are difficult to count, but on one specimen crushed on a slide they were readily determined to be 172 in number, by photographing and then counting them on the photograph. The longest spines average 12 micra in length.

Vitelline follicles (fig. 11, Vit) are clustered into an extensive vitellarium surrounding either intestinal caecum (figs. 1 and 5). The vitel-

line areas of the two sides do not unite anteriorly, but usually do so posteriorly. The paired yolk ducts and their short lateral branches can be traced even in whole mounts laterally as far as a point dorsal to either intestinal caecum, but even serial sections of specimens other than *well-extended* ones, fail to show continuations from that point. Goto mentions being unable to trace the yolk-duct system farther. In longitudinal sections of well-extended individuals the secondary yolk ducts (fig. 2) may be seen lying parallel to, and above, the intestinal caeca, and extending the length of the vitelline area. There are indications of small lateral and median branches from the secondary yolk ducts immediately dorsal to the intestinal out-pocketings in sections of some specimens. Because of their vagueness they were not figured. These are probably the primary yolk ducts connecting directly with the follicles.

The vagina is a dorsally located tube, usually sperm-filled, with an external opening about one sixth of the animal's total length from the anterior end. Posteriorly the vagina bifurcates to join the paired yolk ducts. The latter proceed ventro-posteriorly around the vas deferens and uterus to unite into an unpaired yolk duct which empties into another duct, described below, near the base of the oötype.

The tightly-folded beginning of the ovary is located on the same level as the anterior testicular lobule, but ventral to it (fig. 4), instead of being entirely anterior to the testes as Goto shows. From the median edge of this tightly folded portion in which the eggs are small and immature, the tube-like ovary (fig. 2) courses forward, curves to the left, redoubles upon itself to curve back toward the right in an anterior loop which contains large eggs, and terminates on the right at the small oviduct. The inconspicuous, kinky oviduct enlarges into a seminal receptacle. The latter slopes ventro-mediad to unite with the genito-intestinal canal. The common duct formed by their fusion passes farther to the left, is joined by the unpaired yolk duct, and enters the base of the oötype through a corona of highly refractive bodies (figs. 1, 2, and 4, Q). This bright structure received considerable attention from Lorenz who called it a "quastenförmiges" organ, and noted that the shell apparently grew out of it. Goto dismisses this "Quaste" as being the efferent ducts of unicellular shell glands situated far back, and does not figure the organ. In Puget Sound forms the bodies are consistently present, although their size varies. Ducts lead to them from a group of cells lying ventrally around the base of the genito-intestinal canal. The oötype in life exhibits great changeability and actively pushes the egg, which is being formed, forward and backward. Yolk within the yolk-duct-genito-intestinal-canal complex shoots from side to side. Vogt describes similar activity within *Microcotyle labracis*. The egg shell cannot be seen within the oötype until the moment of emergence into the uterus. It is assumed

that the refractive bodies, "Q", are, as Lorenz has suggested, reservoirs for the actual shell material which their contents greatly resemble, and, further, that the unicellular glands around the oötype secrete a fluid which passes through the minute pores in the wall of the anterior part of the oötype (fig. 14) and which serves merely to harden the shell.

The ciliated uterus is surrounded throughout most of its length by small, close-lying nuclei (figs. 3, 4). It leads directly to the postero-ventral edge of the genital atrium. One egg has been seen to lie behind, but never beside, another within the uterus. The most perfect eggs issue from the genital atrium singly, although, if no rough object is available upon which to catch the filament of each egg as it is laid, then a cluster of eggs with tangled filaments hangs at the opening of the genital atrium. Eggs (fig. 10) average 65×240 micra, exclusive of shell material, and have a short posterior, and a long anterior, filament. The egg consists of a central ovum, surrounded by yolk material with which sperm cells are undoubtedly mixed. It is covered by a spindle-shaped shell of horny consistency. As many as 24 eggs may be laid within a few hours while an animal lies in a dish of sea water.

SUMMARY

1. *Microcotyle sebastis* Goto is recorded from the Pacific coast of North America.

2. A series of body measurements is given.

3. These specimens are shown to be intermediate between those of Goto and of Yamaguti in regard to sucker skeleton and oesophagus.

4. A detailed description of the sucker skeleton is given.

5. Observations on living material are presented.

6. Secondary yolk ducts are described.

EXPLANATION OF FIGURES

Drawings and semi-diagrammatic drawings of *Microcotyle sebastis* were made with the aid of a camera lucida. Diagrams are from reconstructions. Photograph retouching was done only in fig. 14.

References Cited

Galigher, A. E. 1934.—Essentials of practical microtechnique. (Albert E. Galigher, Inc., Berkeley, Calif., 288 pp.)

Goto, S. 1895.—Studies on the ectoparasitic trematodes of Japan. Jour. Coll. Sci., 8: 1–273.

Lorenz, von L. 1878.—Ueber die Organisation der Gattungen *Axine* und *Microcotyle*. Arb. z. Inst. Wien, 1: 405–436.

Price, E. W. 1934.—A new term for the adhesive organs of trematodes. Proc. Helminthol. Soc. Wash., 1: 34.

Vogt, C. 1878.—Ueber die Fortpflanzungsorgane einiger ectoparasitischer mariner Trematoden. Z. für wiss. Zool., 30: (suppl.) 306–342.

Yamaguti, S. 1934.—Studies on the helminth fauna of Japan. Part 2. Trematodes of fishes, I. Jap. Jour. Zool., 5: 249–541.

Abbreviations used in figures:

a,	Antero-lateral skeletal element.
Ant Su,	Anterior sucker.
b,	Postero-median projection of "a".
Br,	Brain.
c,	Postero-lateral skeletal element.
Ex P,	Excretory pore.
Gen Atr,	Genital atrium.
G I C,	Genito-intestinal canal.
G I P,	Genito-intestinal pore.
Int,	Intestine.
J,	Large, median skeletal element.
L N,	Lateral nerve.
m,	Median "dagger-shaped" skeletal element.
Mo,	Mouth.
Oes,	Oesophagus.
Oot,	Oötype.
Ov,	Ovary.
Ovid,	Oviduct.
p,	Prismatic portion of sucker.
Pen,	Penis.
Ph,	Pharynx.
Pigm,	Pigment.
Po H,	Posterior haptor.
Pro,	Prostate gland.
Pr Yk D,	Paired yolk duct.
P S,	Posterior sucker.
Sec Yk D,	Secondary yolk duct.
Sem Rec,	Seminal receptacle.
Sem Ves,	Seminal vesicle.
sm,	Muscle of posterior sucker.
St Gl,	Sticky gland or anterior haptor.
t,	Tendon.
Tes,	Testis.
Ut,	Uterus.
Ut P,	Uterine pore.
Vag,	Vagina.
Vag Op,	Vaginal opening.
V D,	Vas deferens.
Vit,	Vitelline follicle.
V N,	Ventral nerve.
X,	Descending excretory canal.
Y,	Ascending excretory canal.
Yk D,	Unpaired yolk duct.

Plate I. *Microcotyle sebastis*

Fig. 1. Drawing of entire specimen, ventral aspect. ×24.

Fig. 2. Semi-diagrammatic dorsal view of reproductive system. ×50.

Fig. 3. Mid-sagittal section of anterior third of body viewed from the right side. Well extended specimen. Drawing. ×110.

Fig. 4. Semi-diagrammatic reconstruction of middle third of body showing most of the central reproductive organs as seen from the right. From same specimen as, and continuous with, fig. 3. ×110.

Fig. 5. Outline drawing of whole specimen viewed from the left. Vitelline area shaded. ×12.

Fig. 6. Drawing of posterior sucker skeleton as seen almost directly from behind. ×390.

Fig. 7. Mid-sagittal section of a posterior sucker. Drawing. ×320.
Fig. 8. Sagittal section through lateral part of a posterior sucker. Drawing. ×320.
Fig. 9. Latero-posterior view of median elements of sucker skeleton. Drawing. ×700.
Fig. 10. Drawing of egg. ×64.

PLATE II. *Microcotyle sebastis*

Fig. 11. Photograph of anterior portion of a living specimen in dorsal aspect. ×115.
Fig. 12. Photograph of terminal portion of posterior haptor of living specimen. ×105.
Fig. 13. Dorsal view of brain and connectives. Diagram. ×160.
Fig. 14. Retouched photomicrograph of sagittal section through anterior portion of oötype showing perforations in its wall. ×300.

PLATE I

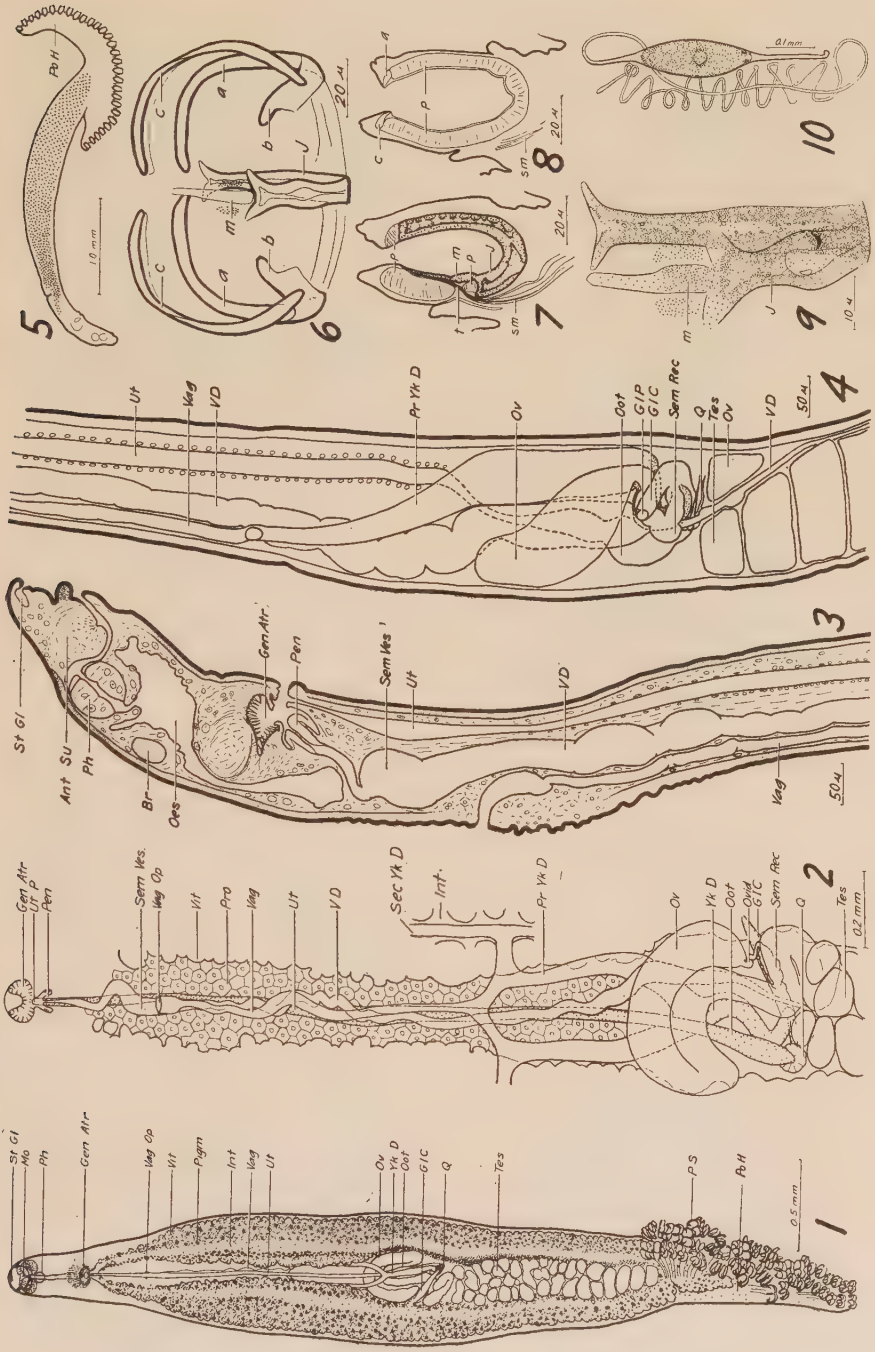
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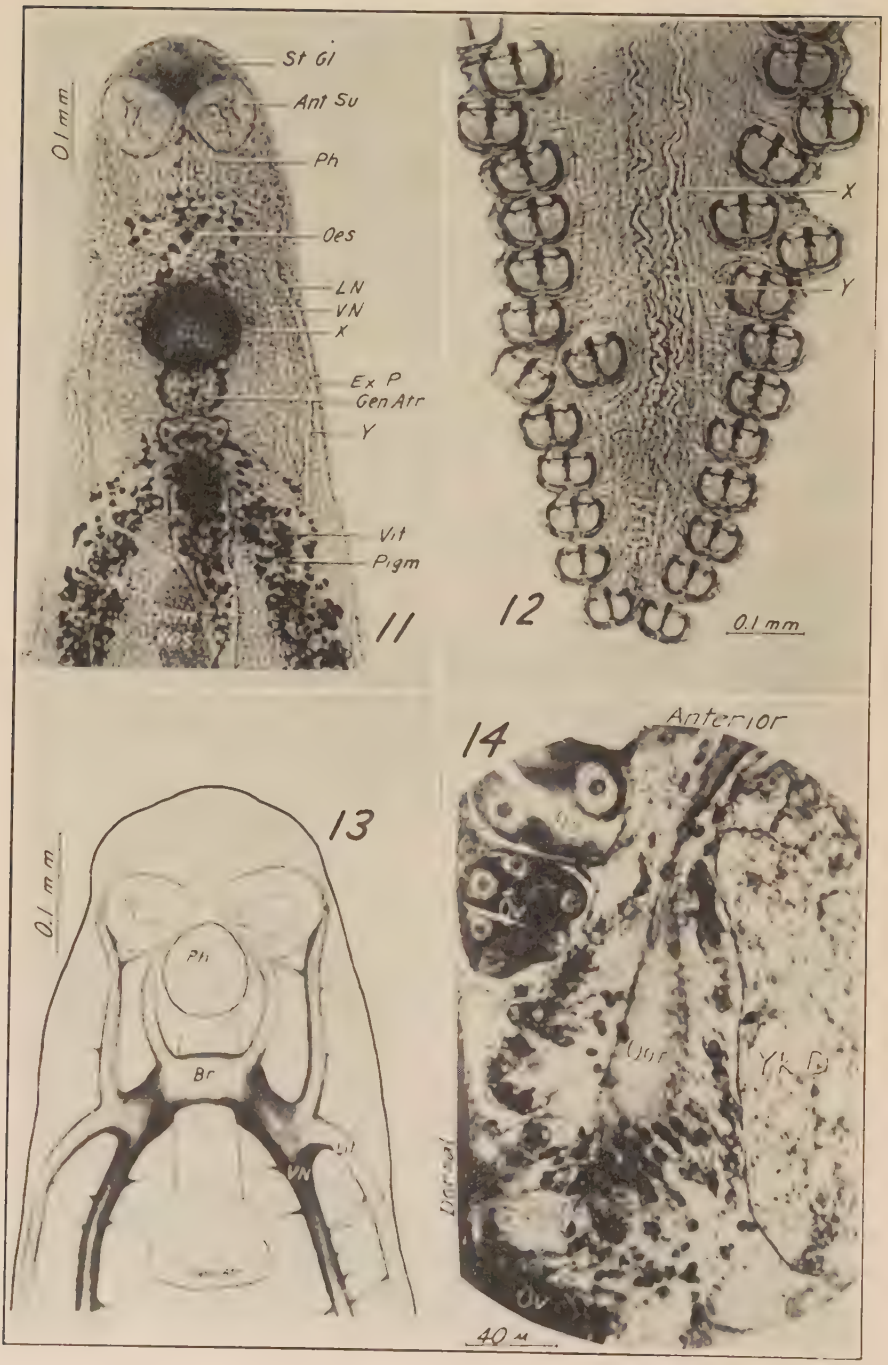
PLATE II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RESEARCH NOTES

STUDIES ON OOCYST PRODUCTION IN AVIAN COCCIDIOSIS. III. PERIODICITY IN THE OOCYST PRODUCTION OF EIMERIAN INFECTIONS IN THE PIGEON

Previous accounts of diurnal periodicity in the oocyst-production of coccidial infections (Boughton, 1933, Amer. Jour. Hyg., 18: 161–184; 1937a, Amer. Jour. Hyg., 25: 203–211; Boughton *et al.*, 1935, Jour. Exp. Zool., 70: 55–74) have dealt with coccidia belonging to the genus *Isospora* parasitic in passerine birds. The present case of periodicity involves a coccidian of another genus and a bird host of a different order. These are *Eimeria* and the common pigeon (*Columba* sp.). Presumably the coccidian species was *Eimeria labbeana* Pinto, although no detailed observations were undertaken to establish its identity. A preliminary account of the early phases of the present study has appeared in abstract form (Boughton, 1934, Jour. Parasit., 20: 329).

Five pigeons, trapped in Boston in November, 1933, were placed together in a cage measuring 24 × 24 × 12 inches and their combined fecal samples examined for the 7-day period, November 13–19, 1933. All five were known to be infected when captured, and they continued to pass oocysts while under observation in the laboratory. A wire-mesh floor permitted the feces to drop through to a collection paper placed under the cage. All available fecal material was taken at stated intervals, *i.e.*, at 15, 21 and 9 o'clock. These collections comprised respectively the *mid-day, evening,* and *night* samples, the first two representing 6 hours and the last, 12 hours. Subsequently these samples were treated and dilution counts made on them in the routine manner previously described (Boughton, 1937, Amer. Jour. Hyg., 25: 187–202), with the exceptions that large samples were mixed by grinding and oocyst-quantities were determined from the average of two counts.

The essential data on the group for the 7-day period are given in Table 1, a perusal of which reveals the following: (a) the proportionate distribution of fecal

TABLE 1.—*Data on five pigeons confined as a group in same cage*

Day	Period (o'clock)	Dry-wt. feces (in grams)	Oocysts per gram (in thousands)	Total oocysts (in thousands)	Proportions per period	
					Feces	Oocysts
1	9–15	7.2	539	3882	3	8
	15–21	5.3	121	640	2	1
	21– 9	14.9	6	101	5	< 1
2	9–15	6.1	215	1319	2	7
	15–21	4.6	100	461	2	2
	21– 9	14.9	5	83	6	< 1
3	9–15	4.8	838	4058	3	7
	15–21	2.5	528	1320	2	2
	21– 9	9.1	39	358	5	1
4	9–15	4.9	1036	5078	2	8
	15–21	5.7	194	1100	2	2
	21– 9	16.0	13	205	6	< 1
5	9–15	6.4	552	3535	3	9
	15–21	3.4	49	168	1	< 1
	21– 9	14.3	6	80	6	< 1
6	9–15	6.0	557	3486	2	8
	15–21	5.3	82	435	2	1
	21– 9	15.8	14	228	6	1
7	9–15	7.4	306	2268	3	7
	15–21	4.8	147	708	2	2
	21– 9	11.2	10	112	5	< 1
All 7 .	9–15	42.9	....	23627	2	8
	15–21	31.6	....	4832	2	2
	21– 9	96.3	....	1168	6	< 1

output for the three collection periods is strikingly uniform from day to day for the 7 days tested; (b) the same is true of oocyst output; (c) the proportionate distributions of fecal and of oocyst output are distinctly different in character, that for feces being on the order of 2–2–6 and that for oocysts, 8–2–1 for the *mid-day–evening–night* samples.

From these facts, it is evident that fecal output is not paralleled by oocyst elimination, for, whereas the former is distributed evenly throughout the 24 hours (as far as can be judged from the 3 samples taken), the latter is characterized by a concentration for the *mid-day* period, 9–15 o'clock. In fact, 7 to 9 parts in 10 of the daily oocyst total are discharged in this 6-hour *mid-day* period, during which only 2 to 3 parts in 10 of the daily fecal output are discharged.

In order to determine whether this concentration of oocysts was characteristic of all five birds individually, they were placed in separate cages and samples were collected over the 2-day period, November 26–27, 1933. The data are given in Table 2, from which it is evident that the individual hosts show a concentration of

TABLE 2.—*Data on five pigeons confined as individuals in separate cages*

Bird	Period (o'clock)	Dry-wt. feces (in grams)	Oocysts per gram (in thousands)	Total oocysts (in thousands)	Proportions per period	
					Feces	Oocysts
			First 24-hour Period			
	9–15	0.8	884	724	3	10
1	15–21	0.4	55	22	2	< 1
	21– 9	1.2	8	9	5	< 1
	9–15	0.5	540	259	3	10
2	15–21	0.2	14	3	1	< 1
	21– 9	0.8	5	4	6	< 1
	9–15	0.6	0	0	2	0
3	15–21	0.2	0	0	1	< 1
	21– 9	2.0	1	2	7	10
	9–15	1.7	4	7	3	9
4	15–21	1.1	0	0	2	0
	21– 9	2.5	0	1	5	< 1
	9–15	0.9	110	96	3	10
5	15–21	0.4	4	2	2	< 1
	21– 9	1.3	1	1	5	< 1
	9–15	4.5	...	1087	3	10
All 5 .	15–21	2.2	...	26	2	< 1
	21– 9	7.8	...	18	5	< 1
			Second 24-hour Period			
	9–15	0.6	412	225	3	9
1	15–21	0.2	146	28	1	1
	21– 9	1.3	1	1	6	< 1
	9–15	0.3	406	114	2	6
2	15–21	0.1	530	74	1	4
	21– 9	0.9	4	3	7	< 1
	9–15	0.7	506	374	3	10
3	15–21	0.4	23	8	1	< 1
	21– 9	1.9	1	2	6	< 1
	9–15	1.3	809	1052	3	9
4	15–21	0.8	164	136	2	1
	21– 9	2.5	1	2	5	< 1
	9–15	0.6	242	145	..	9
5	15–21	0.1	26	4	..	< 1
	21– 9	1.1	15	17	..	1
	9–15	3.5	...	1941	3	9
All 5 .	15–21	1.7	...	251	1	1
	21– 9	7.7	...	25	6	< 1

oocysts during the *mid-day* period just as did the group as a whole. The single exception to this rule is the first 24-hour record of Bird 3, in which an unusually

low count gives what may fairly be considered an atypical distribution by periods. Likewise the fecal proportions are consistent for individual birds and agree closely with those obtained on the group. The summaries of Table 2 are directly comparable to the entries for each of the 7 days in Table 1.

A comparison of the figures in Table 1 and 2 reveals that the birds showed slightly smaller concentration of oocysts when caged together than when isolated. The reason for this difference is not entirely clear. It may depend upon a difference in the speed with which a given particle is carried through the intestine under the two conditions. Such a difference in speed need not be inconsistent with the fact that the group of birds gave fecal proportions almost identical with those for the isolated birds. For some reason, the birds fed better when caged together and, consequently, had greater volumes of intestinal content. If it is assumed that oocysts travel more slowly when being carried in these larger volumes, it appears logical that a portion of the oocysts released from the intestinal epithelium during the *mid-day* period might be retained long enough to appear in the feces collected during the following *evening* period. This would account for the proportionate distribution of oocyst output exhibited by the birds when examined as a group. When the speed of passage through the intestine is more rapid, as seems to be the case in birds which have fed lightly, the appearance of the oocysts in the feces would coincide more sharply with their release from host tissues. This would account for the apparently greater concentration of oocysts exhibited by the isolated birds. Perhaps it should be pointed out that in pigeons, as in passerine birds, the passage of material through the intestine is not complicated by the presence of functional caeca.

The concentration or peak of oocysts during the *mid-day* period cannot be explained as due simply to an increased fecal output for that period. This is evident from the marked differences in proportions of fecal material and oocyst output for the three collection periods. It must depend, therefore, upon a periodic release of the oocysts from the host tissues, as is the case with *Isospora* of passerine birds.

The peak of oocyst-production for the pigeon *Eimeria* occurs approximately 6 hours earlier than that for the sparrow *Isospora*. Further observations are required to determine to what extent the periodicity reported here simulates that of *Isospora* in being dependent upon daily changes in host activity.

The present report emphasizes again a point brought out in earlier work (Boughton, 1933, *l.c.*), *i.e.*, whenever there is a diurnal periodicity in oocyst production considerable caution must be exercised in interpreting negative records in fecal surveys. Furthermore, oocyst numbers in fecal smears, when considered without regard to periodicity, are bound to give erroneous impressions of the degree of infection.

This paper is a contribution from the Department of Comparative Pathology, Harvard Medical School, Boston, Mass. The writer is indebted to Dr. E. E. Tyzzer for providing facilities in his laboratory for carrying out this study.—Donald C. Boughton, *Fellow of the National Research Council*, 1932–1934.

ON THE MATURATION AND THE HATCHING OF THE EGGS OF THE CESTODE *TRIAENOPHORUS CRASSUS* FOREL FROM CANADIAN FISH

The only paper hitherto published dealing with the maturation and the hatching of the eggs of *Triaenophorus* from Canadian fish is that of Newton (1932, Contr. Canad. Biol. Fish., 7: 343–360). This author obtained his material from *Esox lucius* L. in Western Canada. He described the species under the name *T. tricuspidatus* (Bloch) (-*T. nodulosus* Pallas), but I have shown (1935, J. Parasit., 21: 260–263) that *T. crassus* Forel is the common species in *Esox lucius* and that Newton presumably made his observations on the latter species. Newton states that no sexual development of the parasite could be detected between the months of

May and August inclusive, and that fully ripe eggs were present in February. With regard to the hatching of the eggs Newton states that coracidia appeared 15 days after the eggs were placed in water and continued to appear for a further 15 days. He says: "These coracidia are extremely small, measuring 6 μ in diameter"; further: "The posterior portion of the embryo appeared darker, but owing to the extremely small size it was impossible to identify this darker portion as the hook-bearing region."

The following table summarizes my observations on the maturation of *T. crassus,* taken from *Esox lucius* at several localities in Ontario and Manitoba at various times of year.

Quality	Date	Stage of Maturation
L. Winnipeg at Gimly	28– 6–31	No trace of genitalia.
L. Moose, Ontario	2– 7–36	No trace of genitalia.
L. Winnipeg at Matlock	20– 7–33	No trace of genitalia.
L. Winnipeg at Matlock	10– 7–33	No trace of genitalia.
L. Winnipeg at Gimly	15–10–31	First rudiments of genitalia.
L. Winnipeg at Gimly	30–10–31	Genital organs developing.
L. Winnipeg at Gimly	21–11–31	Genital organs developed; no eggs.
L. Winnipeg at Gimly	14–12–31	Eggs in uterus.
L. Winnipeg at Gimly	9– 1–32	Eggs in uterus.
L. Winnipeg at Gimly	2– 3–32	Eggs in uterus.
L. Winnipeg at Gimly	1– 4–32	Eggs in uterus, embryos not yet outlined.
L. of the Woods, Ont.	5– 4–35	Uterus filled with eggs, embryos not yet outlined.
L. Winnipeg at Matlock	3– 5–33	Eggs with well developed embryos.
L. of the Woods, Ont.	10– 5–35	Gravid parasites together with the new infection.
L. Nipissing, Ont.	17– 5–35	Gravid parasites predominate. New infection has also taken place.
L. Nipissing, Ont.	28– 5–35	Both gravid and immature parasites present.

Observations were made on the dates indicated on the condition of the eggs and their hatching. The eggs were kept at room temperature covered with a layer of water 5 mm. to 10 mm. deep. The results were as follows:

I. April 8, 1935. From Lake of the Woods. Embryos not yet outlined in the eggs. The eggs remained until May 26 without showing any sign of development and finally disintegrated.

II. May 12, 1935. From Lake of the Woods. Eggs from the uteri of the parasites showed embryos clearly outlined, with six hooks, and moving actively in the shell. Eggs washed out of the faecal material of the fish were still further developed and started to hatch after 3 hours in water. Those taken from the parasite showed the first eclosions after 32 hours. Hatching continued for 6 days.

III. May 20, 1935. From Lake Nipissing. Embryos outlined, but not as clearly as in No. II. First movements of embryos were observed after 2 days. Hatching started after 4 days and continued for 7 days.

IV. May 31, 1935. From Lake Nipissing. Hatching started after 3 days and continued for 8 days.

The eggs of *T. crassus* are 0.058 mm. long, 0.040 mm. wide. Extreme measurements are 0.540 mm. to 0.064 mm. by 0.036 mm. to 0.044 mm. The eggs are usually white in colour but when ripe they are brown. The uteri of mature tapeworms appear to the naked eye like a row of brown dots along the strobila.

The movements of the coracidia within the eggs and the hatching of numerous eggs were observed with the aid of a dark-field condenser. The movements at first are very slight and occur periodically. Gradually they become more energetic and, before hatching, the coracidium moves very actively. This activity sometimes continues for several hours although usually it takes place only 15 to 20 minutes before hatching. By a sudden movement the operculum opens, the coracidium elongates and in a few seconds it passes through the opercular opening and swims away. The operculum either remains open or closes after the eclosion of the coracidium; sometimes it becomes detached from the shell. The larva swims about by rotating and forward movements. The rotation is slower than the forward movement and there-

fore less noticeable. After 3 to 4 days the coracidium gradually loses its cilia, ceases the movements and remains on the bottom of the dish. In several cases it was noticed that the outer covering, with the cilia, was cast off.

Immediately after eclosion the coracidia have approximately the dimensions of the egg-shell, but in about half an hour they exceed the size of the latter, measuring 60 μ to 70 μ in length and 50 μ to 60 μ in diameter. The cilia are 10 μ to 15 μ long. There is a tuft of cilia 30 μ to 35 μ long at the end directed forward when the coracidia are swimming. The hooks of the coracidia measure 13.5 μ to 15 μ.

It will be noted that my observations do not confirm Newton's and they are published for this reason. Whereas he failed to observe sexual development between May and August my results show that the eggs were fully developed and ready to hatch in May, whilst in February, when he found mature eggs, they were, in my experience, only just appearing in the uterus. Furthermore we differ materially with regard to the measurements of the coracidia.

Diaptomus oregonensis is presumably one of the copepods which serves as the intermediary host for *Triaenophorus* in Canada. This copepod was common in plankton samples taken by Dr. R. Langford from shallow water in Lake Nipissing on the 10th to 16th of June and several specimens were found infected with a procercoid, apparently *Triaenophorus*.—Ella Ekbaum, *Department of Biology, University of Toronto, Canada.*

ANOTHER RECORD OF AVIAN SCHISTOSOMES IN NORTH AMERICA

So far as I know there are thus far but six or seven records of avian Schistosomes from North America, *Schistosomatium pathlocopticum* (Jour. Parasit., 9: 183–198), *Paraschistomatium anhingae* (Price, 1929, Proc. U. S. Nat. Mus., Vol. 75, No. 2789), *Ornithobilharzia pricei* (Wetzel, 1930, Proc. U. S. Nat. Mus., Vol. 78, No. 2846), *Microbilharzia chapini* (Price, *l.c.*), *Heterobilharzia americana* (Price, *l.c.*), and *Bilharziella polonica* (Price, *l.c.*) and the records of *Ornithobilharzia* (Linton, 1929, Proc. U. S. Nat. Mus., Vol. 73, No. 2722) which are of uncertain status (Price, *l.c.*, p. 18). The following note may therefore be of interest to parasitologists.

A pair of schistosomes was found *in the rectum* of a marbled godwit (*Limosa fedoa*) at La Jolla on December 19, 1936. Some of the details were worked out on the living worms and a few additional points noted in the mounted specimens. Unfortunately, the female was destroyed in the attempt to section her and the sections of the male are not very good.

These worms do not appear to be referable to any genus thus far described, although corresponding most nearly to *Ornithobilharzia*. They differ from this genus as described by Price (*l.c.*) however in the relative sizes of male and female, the latter being slightly longer than the male in my specimens, whereas in the former the male is the longer, and in the absence of cuticular spines. In this connection, Linton (*l.c.*, p. 27) states that in one case observed by him the female was at least as long as the male. Owing to the bent form of the female after her expulsion from the gynecophoric canal of the male by pressure of a cover glass, it was impossible to obtain accurate measurements, but she appeared to be about 1–2 per cent longer than her partner. From *Microbilharzia*, the only other genus to which they may be related, they differ chiefly in number and position of the testes, which in my specimen approximate 40 in number and are located in the middle third of the worm or slightly more posterior, while in the former they are 18–20 in number and are pre-equatorial in position.

From such details as are available the following description is given:

Male, 3.9 mm. long × .34 in dorso-ventral diameter, in a partly extended condition; oral sucker .139, pedunculate acetabulum .178 in diameter; anterior end somewhat flattened, body and tail more nearly circular in cross section; gynecophoric canal commencing just posterior to the acetabulum and extending to near the posterior end of the body; testes about 40, arranged in an irregular double row

in about the middle third of the body; excretory system opening at the posterior end of the worm and extending forward as a single tube for about 1/7 of the length of the body, where it divides into two branches, which extend forward to the anterior end giving off numerous side branches en route.

Female, filiform, about 0.80–1.00 mm. in diameter; oral sucker about .065 in diameter, pedunculate acetabulum .088×.148; gonopore a short distance behind the acetabulum; egg single, ovary in anterior 1/3 or 2/5 of body; vitellaria occupying about 2/5 of the body, rather more post- than pre-equatorial in position, somewhat pyriform in shape and filling most of the diameter of the worm.

It is interesting to note that Linton (*l.c.*) also found all of his schistosomes in the intestine of their avian hosts. He says (p. 27) that "no search was made in the blood vessels or gall bladders, but in the process of removing and examining the viscera blood parasites might easily be liberated and appear in the washings from the alimentary canal." In the godwit from which my specimens were obtained the viscera, including the heart, had been considerably punctured by shot, and there was a large clot in the pericardial sack, so that the proper location of the parasites in their host is uncertain.

While my specimens are apparently not referable to any described form, I consider it unwise to describe them as new on the basis of such poor and scanty material. I am indebted to Dr. H. U. Sverdrup, director of the Scripps Institution of Oceanography, for the privileges of the institution, where these data were obtained. —R T. Young, *La Jolla, Calif.*

THE LOUSE FLY, *LYNCHIA FUSCA*, PARASITE OF THE OWL, *BUBO VIRGINIANUS PACIFICUS*, A NEW VECTOR OF MALARIA OF THE CALIFORNIA VALLEY QUAIL

While investigating the causes for the reported reduction in the Valley quail, *Lophortyx californica* Shaw, O'Roke in 1927 (O'Roke, 1928, Calif. Fish and Game 14: 193–198) discovered a *Haemoproteus* infection of the blood cells. He observed that the most heavily parasitized birds were anemic compared to normal birds and seemed to be weaker and not so active. O'Roke later (1929, Science, 70: 432) named this parasite *Haemoproteus lophortyx* and in 1930 (Univ. Calif. Publ. Zool., 36: 1–50) concluded that transmission is effected by the louse fly, *Lynchia hirsuta* Ferris. Although O'Roke was not successful in obtaining transmission by means of the bite of this fly, he did demonstrate oökinetes, oöcysts, and sporozoites in the insect.

The investigation here reported was begun in order to determine if any other vectors could be found which may possibly transmit the parasite of quail malaria, particularly because of the apparent scarcity of *Lynchia hirsuta*. Experiments were made with the hippoboscid fly, *Lynchia fusca* (Macquart), taken from the owl, *Bubo virginianus pacificus* Cassin, and with three species of mosquitoes—namely, *Anopheles maculipennis* Meig., *Culex tarsalis* Coq., and *Aedes dorsalis* Meig. Although all three species of mosquitoes sucked the blood of infected birds and numerous tests were made, no transmissions were effected, except possibly in one instance with *Anopheles maculipennis* in which case the identity of the organism remains in doubt. Positive results with the hippoboscid are here described.

Trapping birds for experimental purposes was done under permit from the Division of Fish and Game. Birds trapped early in November in the Berkeley hills showed a high percentage of infection with malaria—*i.e.*, of over 50 birds examined, 60 per cent were infected. Negative birds were secured at the State Game Farm at Yountville. To determine whether a bird was negative or not the following test was made. Two birds, one of which was positive to *Haemoproteus lophortyx*, and one in which no *Haemoproteus* could be found after several examinations, were examined daily to determine: 1, if at any time gametocytes could not be found in the infected bird, and 2, if at any time gametocytes could be found in the bird believed to be free from infection. Blood smears were taken from each bird daily, and if no gametocytes could be found in the negative bird after 30 minutes examination of the smear, it was considered negative for that day. This particular test

was begun on March 8, 1936, and concluded April 30, 1936, during which time no gametocytes were found in blood taken from the negative bird. In the infected bird gametocytes could be found at all times, though varying in intensity from day to day. In fact the infection could be demonstrated in an infected bird during a period of ten months when the experiment was ended. It therefore appears that in a quail infected with *Haemoproteus lophortyx,* (1) gametocytes may always be demonstrated and (2) latent periods in infection during which time no parasites can be found in the blood do not occur in quail malaria. Unsuccessful attempts were made to induce relapse by raising the blood sugar of the negative birds.

On December 9, 1936, eight hippoboscid flies taken from the owl, *Bubo virginianus pacificus,* were brought to the laboratory and identified as *Lynchia fusca* (Macquart), the most widely distributed species of hippoboscid. This fly is considered by Ferris to be the same as *Lynchia americana.* Feeding experiments on quail were tried. The flies were readily attracted to the quail, and rapidly disappeared under the feathers. They were very active, and flew with a buzzing noise. Owing to their very active movements they were exceedingly difficult to capture. The warmth of the bird definitely accelerated their movements. Flies were first merely placed on the bird and allowed to feed, a practice which had to be discontinued because they were destroyed by the birds. A more satisfactory method of feeding the flies was necessary. Other investigators were confronted with the same difficulty—that of the birds eating the flies.

O'Roke records the loss of several flies, when opening the cages for feeding. He was also unable to keep the flies alive in captivity for more than five days.

A method was described by Rees (1934, U. S. Dept. Agri., Bull. 418) for feeding young ticks on the wings of chickens. He placed the ticks in small cloth bags, and tied these over the proximal part of the wing. By using this method of feeding, the flies were easily held in the bag and readily transferred from one host to the other by transference of the bag. The flies were kept alive by this method for 15 days.

In this manner two hippoboscid flies were placed on the wing of quail RB, an infected male bird. Five days later the sack was still attached, and the two flies were present and very active. In the bottom of the sack a pupa and the remnants of another pupal case were found. The pupa had just passed from the prepupal to the pupal stage. It was globular, tan in color, with black tips around the spiracles which are at the posterior end. The anterior end is more rounded. Within a few hours the entire pupa had turned black.

Nine days after the flies had been placed on the infected quail, they were transferred to a quail from the Game Farm which had been negative for the parasites by repeated examination. The transfer from the infected to the negative bird was made December 18.

Four days later the flies were dead. The blood of the bird remained negative until January 14 when very young gametocytes were found. They rapidly increased in size, and within a few days larger stages, and then mature gametocytes were abundant. The bird remained infected for the several months it was under observation.

Thus, the incubation period in the fly, *Lynchia fusca,* appears to be from 9 to 13 days and the incubation period in the quail about 25 days.

These results are comparable to the incubation period of *Haemoproteus columbae,* the organism of pigeon malaria, which is given as 8 to 12 days in the fly, *Pseudolynchia maura,* and 20 to 30 days' incubation period in the pigeon. O'Roke (1930, *l.c.*), after injecting sporozoites of *Haemoproteus lophortyx* into the quail found gametocytes developing after 28 days.—W. B. Herms and C. G. Kadner, *University of California.*

IDENTIFICATION OF STRIGEID CERCARIAE BY DIFFERENCES IN THEIR BEHAVIOR DURING FREE LIFE

Cort and Brooks (1928, Trans. Amer. Mic. Soc., 47: 179–221) pointed out definite specific differences between different species of strigeid cercariae in the

swimming activity and in the position assumed when floating in the water. Such differences have been helpful in the preliminary identification of these cercariae in the studies since that time at the University of Michigan Biological Station. In the last two summers, very extensive examinations have been made of the cercariae found in *Stagnicola emarginata angulata* (Sowerby) in the Douglas Lake region. These investigations have been greatly facilitated by the fact that after separating the collections of snails into bottles, we have learned not only to separate the strigeids from the other types of cercariae but to make a preliminary identification of certain of the strigeid species with a hand lens.

By far the most common of the seven species of strigeid cercaria (for references to the descriptions of these species of cercariae see Cort and Brackett, 1937, Jour. Parasit., 23: 265–280) which have been described from this host in the Douglas Lake region is the cercaria of *Diplostomum flexicaudum.* This is the easiest form to identify because of the bending of the tail when in the floating position to almost an acute angle with the body. Three of these strigeid cercariae, the cercaria of *Cotylurus flabelliformis, C. longifurca,* and *C. dohema,* can be separated from the others by the fact that they swim constantly after their escape from the snail host. Except for *C. dohema,* these species have been rather rare in recent collections, and their identification from swimming activity alone has not yet been worked out.

During the past summer, studies on the behavior of the other three of these strigeid species, the cercaria of *Cotylurus communis, C. laruei,* and *C. yogena,* have been extended so that it is now possible to distinguish them rather easily. Some information is available in the literature on their behavior during free life (Van Haitsma, 1930, Jour. Parasit., 16: 224–230; Cort and Brooks (*l.c.*), and Cort and Brackett (*l.c.*), although no comparison for the purpose of distinguishing them has previously been published.

The cercaria of *C. communis* is considerably larger than the other two and so appears when viewed in the water with a low power lens. For the most of its free life, it floats with the body hanging downward. When a number of the cercariae are watched in a bottle, only a very small proportion of them will be swimming at any one time. Practically all of the resting cercariae of this species hang with the long axis perpendicular to the bottom of the container. When they do swim, they move almost directly upward for only a very short distance. The suspended body is bent somewhat ventrally and contracted so that it appears somewhat more opaque than the tail stem. Another striking characteristic of the resting position is that the furcae form an angle with the tail stem only slightly greater than 90° so that the angle between them approaches 180° and they give with the tail stem almost a T-shaped appearance.

In its resting position, *C. laruei* resembles the cercaria of *Cotylurus communis* in that it hangs perpendicularly and swims straight up. It swims for longer distances than the other species, and the resting period appears to be shorter so that a larger proportion of the cercariae are in motion at the same time. They also appear distinctly smaller as they float in the water, and the body has about the same transparency as the tail stem. A more striking difference still is that the furcae of *C. laruei* in the resting position are held at about right angles with each other so that with the tail stem they form a Y.

C. yogena is very easily distinguished from the cercaria of *Cotylurus communis* or *C. laruei* when free in the water. In the first place, a large proportion of the individuals of this species do not hang perpendicularly, so that when numbers of them are viewed in the water their long axes appear at all angles with the bottom of the container. A much larger proportion of them are in motion at one time, as they are observed free in water, than for either the cercaria of *C. communis* or *C. laruei.* Also, the distance of swimming is much greater, and they swim in all directions changing their direction frequently. As in *C. laruei,* the furcae of *C. yogena* are held in the resting position at right angles to each other.

The length of the resting periods of these three species of cercariae were determined by timing individual cercariae with a stop watch when viewed in the

water with a hand lens. Observations on 20 different individuals of the cercaria of *C. communis* at a temperature of 19–20° C. showed a variation in the resting period from 18–110 seconds with a mean of 40 ± 3.4 seconds. At a higher temperature (33–34° C.), this period was considerably shorter varying in 20 individuals observed from 7–49 seconds with a mean of 30 ± 1.7 seconds. At a temperature of 19–20° C., a series of exactly similar observations on *C. yogena* gave the variations in the resting period from 9–107 seconds with a mean of 23 ± 3.6 seconds, 15 of the 20 observations being below the mean. At the higher temperature (33–34° C.), the variation in this species was from 9–25 seconds with a mean of 15 ± 0.7 seconds. The resting periods of *C. laruei* were observed only at the higher temperature (33–34° C.). This species showed a variation in 20 observations of from 7–47 seconds with a mean of 17 ± 1.7 seconds. It can be seen from these observations that the duration of the resting period of the cercaria of *Cotylurus communis* in this series of observations was significantly longer than that of *C. yogena.* It seems probable also that if the series had been extended the difference between resting period of the cercaria of *C. communis* and that of *Cercaria laruei* would have been found to be statistically significant.—W. W. Cort and Sterling Brackett, *a contribution from the University of Michigan Biological Station and the Department of Helminthology, School of Hygiene and Public Health, the Johns Hopkins University.*

THE NEMATODA AS PARASITES OF AMPHIBIA. III. STUDIES ON LIFE HISTORIES

While examining a large number of Florida Amphibia for their helminth parasites, material became available for the study of the life cycles of two forms of nematodes, one a normal parasite as an adult in the alligator (*Alligator mississippiensis*), and the other in snakes, both water snakes of the genus *Natrix* and land snakes of the genus *Coluber.*

1. *Ophidascaris labiatopapillosa* Walton, 1927

Encysted in the stomach muscles, mesenteries, and body muscles of *Amphiuma tridactylum, Rana aesopus, R. catesbiana* and *R. sphenocephala* were larval forms of a nematode that at first was regarded as a filariid, possibly belonging to the genus *Icosiella.* Feeding experiments with specimens of *Natrix rhombifera* and *Natrix sipidon sipidon* which had been maintained in the laboratory for over eight weeks and regarded as parasite-free on the basis of fecal examinations, gave rise to an adult form in the stomach of the snake which proved to be, not a filariid, but an ascarid, seemingly most nearly like *Ophidascaris labiatopapillosa* Walton, 1927 (Proc. Acad. Nat. Sc., Phila., 79: 49–163), earlier reported from a blacksnake (*Coluber constrictor constrictor*) collected in Florida.

The larvae, always encapsulated in the amphibian host, varied in length from less than two centimeters up to twelve centimeters. The lips are poorly developed, showing outlines of three divisions, one provided with two papillae and the other two with one papilla each. The esophagus is simple, slightly increasing in diameter posteriorly. The anus is sub-terminal. Rudiments of the genital system, when present, are mainly in the posterior third of the body.

Both encysted and free larvae from *Amphiuma* and from the three species of frogs were fed to separate snakes. In the case of the larvae from *Amphiuma,* all were ultimately passed by the snake undigested although in every case the capsule had been broken up. In the case of the specimens from the frogs, the larger ones were passed through the intestine undigested, but the smaller larvae (up to 6 cm. in length) were retained. Upon dissection four weeks after feeding, the snake fed larvae from *Amphiuma* showed no nematodes, the snake fed larvae from *Rana aesopus* contained a pair of young Ophidascarids, the one fed larvae from *R. catesbiana* contained an immature male Ophidascarid and the one fed larvae from *R. sphenocephala* contained several immature females and one pair of mature worms, all apparently belonging to the same species, *Ophidascaris labiatopapillosa.*

The adults agree with the original description except that the vulva is median instead of anterior to the mid region. This agrees more nearly with the generic characteristic than did the original description of this species.

Infective eggs from the mature female and also from a female collected from the blacksnake were fed to young *Rana pipiens* which had been laboratory raised. Encysted larvae were collected from the stomach musculature four weeks after feeding which seem to be identical with the original larval forms. Control *R. pipiens* dissected at the same time showed no signs of parasitism.

The life cycle seems to alternate between an amphibian and a reptilian host. Possibly the land-living snakes prey more successfully on the more terrestrial frogs, and the water snakes on the more aquatic amphibia, although no reason seems available to explain the failure of the larvae from *Amphiuma* to develop in a water snake of the genus *Natrix*.

2. *Multicaecum tenuicolle* (Rud., 1819) Walton, 1927 (*l.c.*)

Encysted larvae from the stomach muscles of *Rana catesbiana, R. sphenocephala* and *Siren lacertina* upon dissection were found to possess the multiple caeca (2 anterior and 3 posterior) (Fig. 1) characteristic of the genus *Multicaecum* (Baylis, 1923). Fifty such larvae from *Siren lacertina* were fed to a young alligator (*A. mississippiensis*) which had been in captivity for several months and proven parasite-free by fecal examination. This animal died three weeks later and an autopsy showed the presence of several immature males and females of a form of *Multicaecum tenuicolle* (Rud., 1819) Walton, 1927, earlier reported from the same host. No mature eggs were available for further feeding experiments and feeding of the immature eggs to laboratory raised *R. pipiens* did not result in a new generation of encysted larvae. Control *R. pipiens* were also negative.

Fig. 1. *Multicaecum* larva; from dissection of esophageal region.

While not definitely proven, it seems likely, however, that the genus *Multicaecum* has an alternation of hosts, with the larval stages in amphibia and the adult form in the Crocodylidae.

Contribution from the Biology Laboratories of Knox College, no. 53.—A. C. Walton.

A NEW SPECIES OF BAT FLEA (SIPHONAPTERA) FROM ARIZONA

Myodopsylla collinsi n. sp.

Close to *Myodopsylla insignis* Roths. (1903) and *M. gentilis* Jord. & Roths., 1921, the only previously known North American representatives of this genus, but distinguished by the modified abdominal segments and the heavier thoracic and abdominal vestiture.

The species is described from 3 males and 4 females (no. 9044A) found on 3 bats taken by the writer in an abandoned mine tunnel, Madera Canyon, Santa Rita Mountains, Santa Cruz County, Arizona, May 9, 1933. *Holotype,* a male, *allotype,* a female, and paratypes in the collection of the Rocky Mountain Laboratory, U. S. Public Health Service, Hamilton, Montana. The species is named in honor of Mr. Benjamin J. Collins of the National Institute of Health who recognized it as new.

Length, male, 2 mm.; female, 2.2 mm.

Thorax, male. The pronotum bears a comb of about 42 closely set spines on its apical margin preceded on each side by 18 bristles arranged in 3 rows. The mesonotum bears about 18 bristles on a side also arranged in 3 rows and an apical marginal row of 8 strong bristles. The metanotum bears 8 bristles on a side arranged in 2 rows followed by 14 strong bristles in the posterior marginal row. The mesepisternum bears 12 bristles and the mesepimeron 3. There are no bristles on the meso- and metasterna. The metepisternum bears 4 bristles and the metepimeron 10.

EXPLANATION OF FIGURES

Fig. 1. *Myodopsylla collinsi,* genitalia, male.
Fig. 2. *Myodopsylla collinsi,* 7th sternite, female.
Fig. 3. *Myodopsylla insignis,* 7th sternite, female.
Fig. 4. *Myodopsylla gentilis,* 7th sternite, female.

Female. Chaetotaxy essentially the same as in the male.

Abdomen, male. Besides the apical row each tergite except the first bears 1 row of bristles. The first tergite bears 2 rows of 8 bristles each on a side. The numbers of bristles on a side on tergites 2–7 are as follows: 8, 8, 5, 5, 5, 4. The numbers of apical bristles on a side on tergites 1–7 are about as follows: 14, 12, 12, 10, 9, 9, 9, the lowest bristle on each tergite being below the stigma. The apical bristles in the region of the dorsum are closely set forming false combs, rendering the ascertainment of their approximate number only. Apical teeth are absent. Sternites 4–7 bear bristles as follows: 2, 3, 4, 6 on a side. Antepygidial bristles 2 and are borne on rod-like processes which project over the pygidium a distance of slightly over one third of its diameter.

Female. The number and arrangement of the tergites are essentially the same as in the male. Bristles on sternites 4 to 7 are as follows: 4, 4, 6, 13. Antepygidial bristles also 2 but the bases on which they are mounted do not project beyond anterior margin of pygidium.

Modified Segments, male. Because of distortion in mounting, certain details of the genitalia are obscured. The clasper (Cl. fig. 1) is more produced below the exopodite F than above it and bears a bristle on the apical margin of the lower process P_2. The general configuration of the exopodite is similar to that in *gentilis* and *insignis,* the taper of the dorso-proximal prolongation being however more gradual than in *insignis* and more abrupt than in *gentilis.* There are 3 small bristles near the apex of this prolongation, and 1 slightly distad on the dorsal margin. The 9th sternite is evenly rounded ventrally; the dorsal margin straight except for a low protuberance apically. Apex rounded. There is a strong spine-like bristle near the lower distal margin of this process, another about two diameters proximad, and a third, which is somewhat shorter and submarginal, situated about twice this distance proximad. No ventral processes are discernible. Upper prong of lobe L_1 of the paramere (Par.) curved resembling the claw of a bird. The lower lobe is one third as long and is evenly rounded. Ventral process L_2 of the paramere strongly curved, dilated apically, the posterior margin of the dilation serrate.

Female. Seventh sternite (fig. 2) similar to *insignis* and *gentilis* but upper posterior margin more sharply produced. Since the outlines of the posterior margins of this sclerite in these species have hitherto not been figured, the opportunity is taken to do so (figs. 3 and 4). Stylet as in the foregoing species. Receptaculum seminis appears to be identical with that in *insignis* and *gentilis.*

This paper is a contribution from the Rocky Mountain Laboratory, United States Public Health Service, Hamilton, Montana.—GLEN M. KOHLS, *Assistant Entomologist, United States Public Health Service.*

CAMALLANUS SWEETI N. SP., A NEW SPECIES OF CAMALLANIDAE (NEMATODA).

While conducting investigations on dracontiasis in the Chitaldrug district (Mysore State), South India, it was found that specimens of cyclops collected from one of the step wells in Chitaldrug town were found infected with *Camallanus* larvae under natural conditions. Acting upon a suggestion from Doctor W. C. Sweet, a careful search for the adult worms was made in five of the larger species of fish present in the same step well, of which only *Ophicephalus gachua* (Ham) has been so far found infected.

Out of 148 specimens of *Ophicephalus gachua* 142 or 95.9 per cent were found to be infected with adult *Camallanus* worms in their intestines. The total number of worms present in each of these infected specimens varied from 25 to 180, the males being found usually in larger numbers than females. The immature females and males were found usually in the first half of the intestine, the mature females containing embryos being found in the last half of the intestine.

This nematode appears to be a new species and for it the name *Camallanus sweeti* is proposed in honor of Doctor W. C. Sweet of the Rockefeller Foundation, Mysore State, India, to whom the writer is greatly indebted for the very valuable suggestions, help, and encouragement given.

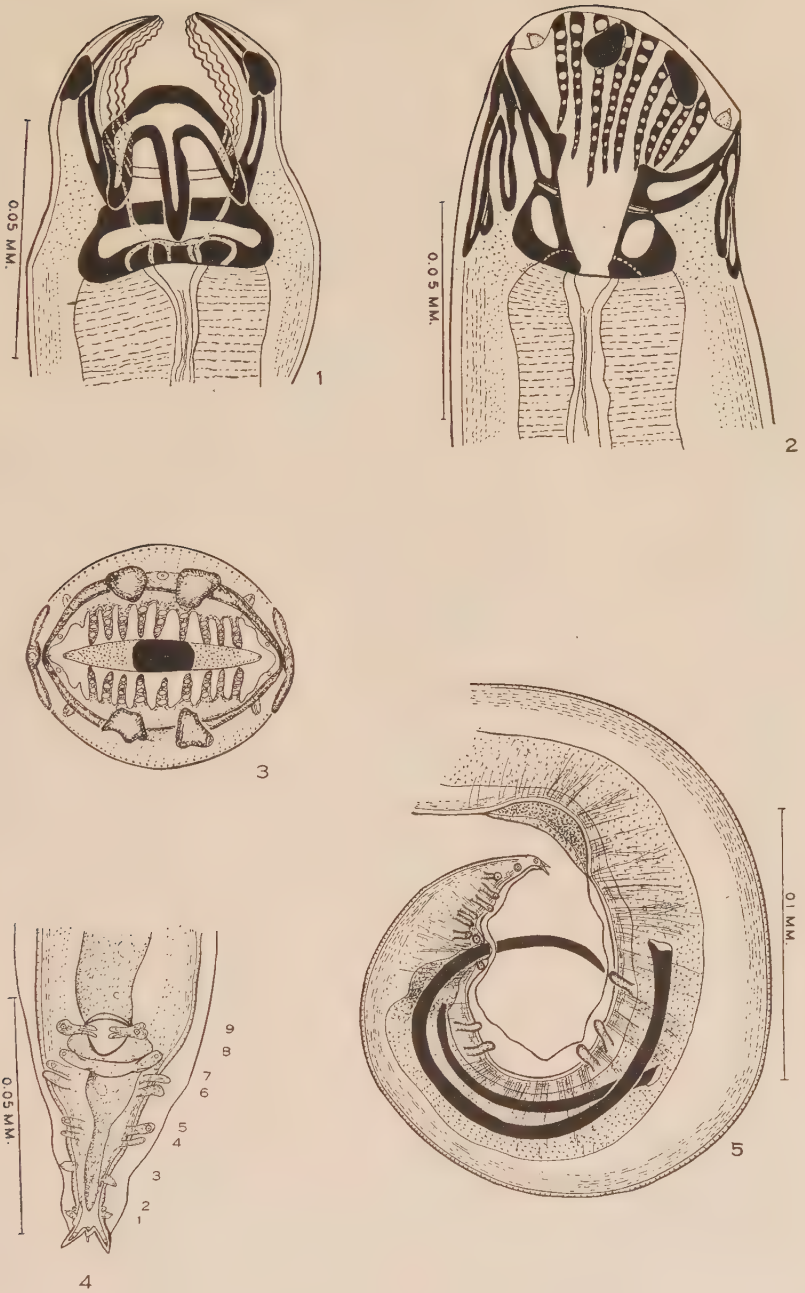


PLATE I

Camallanus sweeti, n. sp.

Fig. 1. Head of female, median view.
Fig. 2. Head of female, lateral view.
Fig. 3. Head, en face view.
Fig. 4. Tail of male, ventral view.
Fig. 5. Tail of male, lateral view.

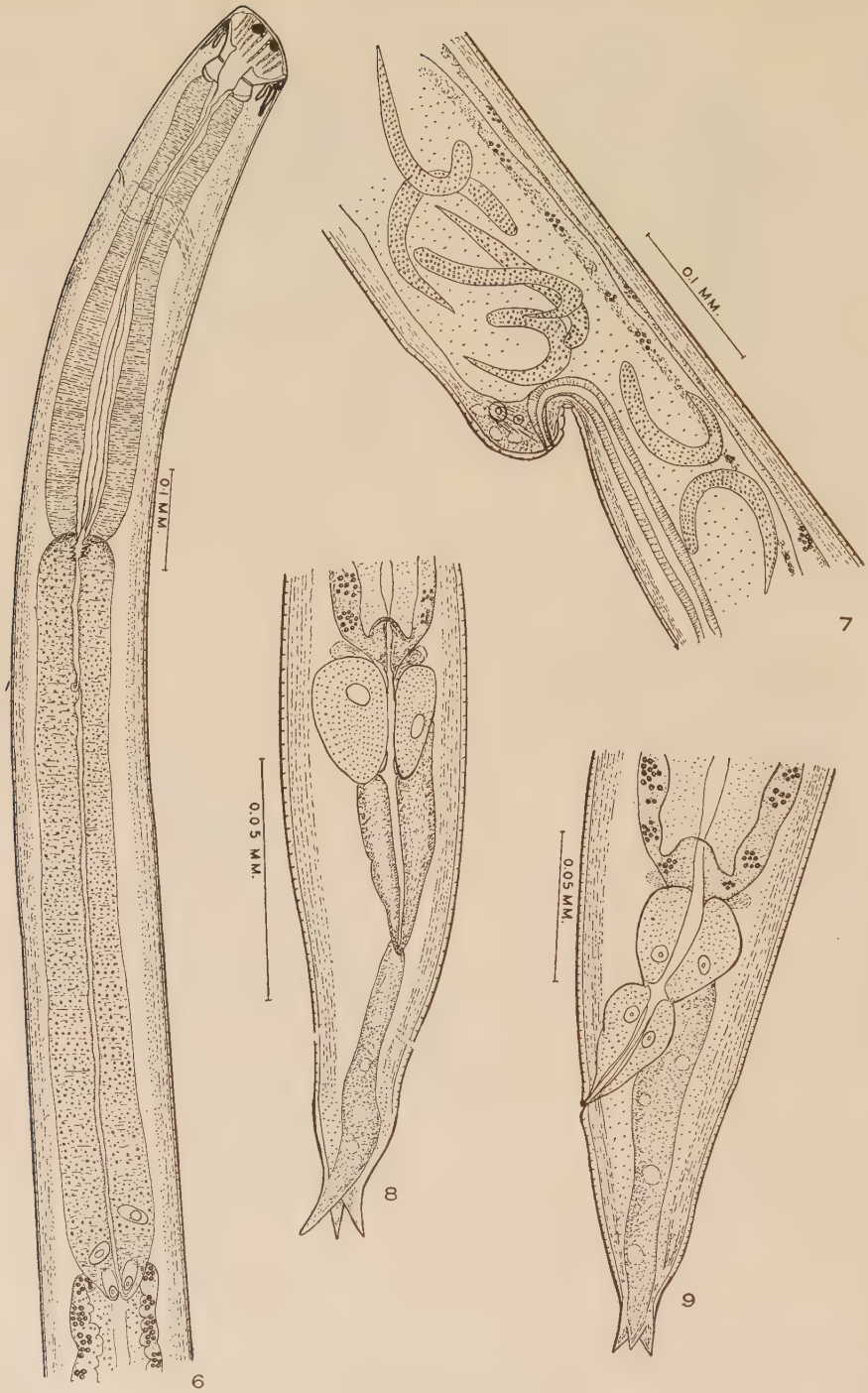


PLATE II

Camallanus sweeti n. sp.

Fig. 6. Female, oesophageal region.
Fig. 7. Vulva of an adult female, lateral view.
Fig. 8. Tail of female, ventral view.
Fig. 9. Tail of female, lateral view.

Camallanus sweeti n. sp.

Description: Stoma, 0.06 to 0.07 mm. long; consists of paired jaws and well developed, wide, chitinous, ring that separates the jaw from the oesophagus (fig. 2); nine longitudinal ridges, beaded in appearance, and of about the same length extend from anterior end to upper margin of chitinous ring; oral opening, wide and surrounded by internal circle of two pairs of small papillae and external circle of two pairs of comparatively more prominent papillae; amphids, indistinct (fig. 3); trident, with median process longest, about 0.046 mm., and two submedians of about equal length, each measuring about 0.025 mm. (fig. 1); two quadrilateral chitinous plates, situated at anterior margin (fig. 2).

Female: 3.2 to 5.5 mm. long by up to 0.15 mm. wide; cuticular striations, fine, not over 4 μ apart; oesophagus, anterior muscular portion, 0.32 to 0.42 mm. (from anterior extremity to commencement of glandular portion), posterior glandular portion, 0.4 to 0.52 mm. (from commencement of glandular portion to extreme end of it); nerve ring, at junction of proximal one-third with distal two-thirds of muscular portion of oesophagus; excretory pore, about 0.16 mm. from anterior extremity (fig. 6); vulva, 2.0 to 3.0 mm. from anterior end, conspicuous and provided with well developed prominent lips; in fertilized females containing embryos, posterior lip pushed to one side by overhanging anterior projection making prominent protrusion on one side of body; in young immature forms such projection not usually found; vagina, narrow and runs back posteriorly to about 0.3 mm. (fig. 7); tail with three mucrones at tip; length varies from 0.05 to 0.07 mm.; in immature forms, the mucrones are very prominent, mediodorsal being noticeably stouter and longer than two ventro-laterals (fig. 8); in mature forms comparatively less prominent and of about same size (fig. 9).

Male: 3 to 3.9 mm. in length and up to 0.13 mm. in width; oesophagus, anterior muscular portion, 0.31 to 0.38 mm. in length (from anterior extremity to commencement of glandular portion); posterior glandular portion, 0.38 to 0.44 mm. in length (from commencement of glandular portion to extreme end of it); tail 0.05 to 0.063 mm. in length; in immature forms mucrones are present at the tip as in females; in mature forms, only ventro-laterals prominently seen, median one considerably reduced in size and seen as a small papilliform projection (fig. 4); genital papillae, 13 to 15 pairs: preanal, 4–6 pairs; circumanal, 2 pairs and postanal 7 pairs; numbering from the posterior extremity, pairs 1 and 2, lateral and in a group; pair 3, ventro-lateral and isolated; pairs 4 and 5, ventro-lateral and in a group; pairs 6 and 7, ventro-lateral and in a group; pairs 8 and 9, circumanal and isolated; preanal papillae variable, 4–6 pairs, subventral to ventro-lateral; in majority of specimens 5 hairs present; spicules, unequal; right, longer and more prominent, measuring 0.21 to 0.30 mm. in length; left, comparatively very much more slender and measures 0.1 to 0.18 mm. length; a sucker-like organ situated at about 0.32 mm. from the posterior extremity (fig. 5).

Discussion: Camallanus sweeti resembles, to a certain extent, both *Camallanus melanocephalus* (Rudolphi, 1819) and *Paracamallanus cythopharynx* (Baylis, 1923), in its having a relatively well developed wide chitinous ring that separates the jaws from the oesophagus. But it differs from them in size and shape of the chitinous ring, and in the spicules being definitely unequal, the right one being nearly twice as long as the left. In *C. melanocephalus* the spicules are subequal and in *P. cythopharynx* the spicules have not been detected. *C. sweeti* appears to be a transitional form between the genus *Camallanus* and *Paracamallanus*. It has been found that the larval forms of this species pass through a stage having a stoma very much similar to that found in the adult in the genus *Paracamallanus;* but in the adults the stoma resembles more that of the genus *Camallanus* than of *Paracamallanus*. This observation suggests that the presence or absence of a large chitinous buccal cavity is not a satisfactory generic character and casts some doubt as to the necessity of keeping *Paracamallanus* as a separate genus.

Life history: The complete life history of *Camallanus sweeti* is at present being worked out and the results will be published in a subsequent paper. From the

observations so far made, this parasite appears to require the intervention of two intermediate hosts, the cyclops (*Cyclops leuckarti*) and a smaller species of fresh-water fish (*Barbus puckelli* or *Lepediocephalocythys thermalis*), before final development can take place in the definite host (*Ophicephalus gachua*). The larvae undergo initial development in the body cavity of cyclops which become infected by feeding on larvae liberated from the adult worms. Further development of the larvae takes place in the intestine of the fresh-water fish when they feed on these infected cyclops. The larvae, after undergoing the preliminary developmental changes in the second intermediate host, remain encysted in the intestinal wall, and the infection of the final host takes place by its feeding on these smaller species of infected, fresh-water fish.

ACKNOWLEDGEMENT

Acknowledgement is made to the International Health Division of the Rockefeller Foundation, for having granted the fellowship which made this work possible. The writer is greatly indebted to Drs. W. W. Cort, G. F. Otto, and P. Parthasazathy for the helpful criticism and advice given in the course of this work. To Dr. B. G. Chitwood the writer wishes to express his gratitude for very valuable help and guidance. This paper is a contribution from the Department of Helminthology, School of Hygiene and Public Health, the John Hopkins University, Baltimore, Md.—V. N. Moorthy, *Fellow of the Rockefeller Foundation from Mysore State, Department of Health, Bangalore, India.*

RUSGUNIELLA KOFOIDI SP. NOV., A NEMATODE (ACUARIIDAE) FROM THE LESSER SCAUP DUCK

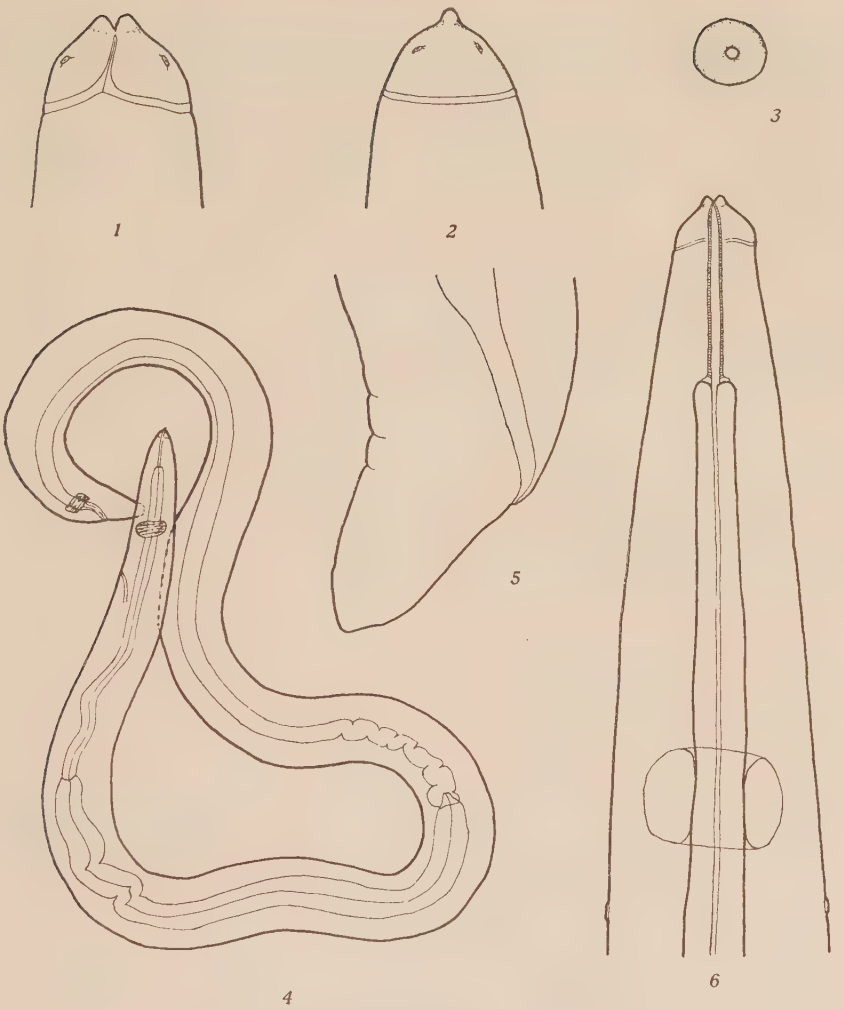
This description of a new species of nematode belonging to the genus *Rusguniella* Seurat, 1919, is based upon seven specimens obtained from a Lesser Scaup Duck, *Nyroca affinis* (Eyton) taken near Bay, California, in November, 1929. All of the specimens are larval forms, none of the sex organs being differentiated. This is the first species of *Rusguniella* to be reported from North America, and the first obtained from the avian order Anseriformes. Thus the known geographical and host ranges for *Rusguniella* are extended.

Rusguniella kofoidi sp. nov. (Figures 1–6.)

Diagnosis: Rusguniella; cordons very narrow but distinct, not granular, extending posteriorly from the base of the lips for a distance of 0.009–0.011 mm.; width of cordons about 0.001 mm.; lips not strongly developed, measuring 0.001–0.002 mm. long by 0.002–0.003 mm. wide; head papillae minute, indistinct; transverse body striations from 416 to 485 per mm. near the middle of the body; postanal region bluntly conical.

MEASUREMENTS

	Range	*Average*
Length	2.2 –2.7 mm.	2.4 mm.
Diameter	0.075–0.095	0.085
Head, diameter	0.011–0.017	0.014
Cervical papillae to head	0.13 –0.16	0.15
Nerve ring to head	0.11 –0.13	0.12
Pharynx, length	0.036–0.040	0.039
Pharynx, diameter	0.002–0.004	0.003
Anterior oesophagus, length	0.31 –0.44	0.37
Anterior oesophagus, diam.	0.011–0.014	0.013
Posterior oesophagus, length	0.58 –0.75	0.66
Posterior oesophagus, diam.	0.026–0.031	0.028
Postanal region, length	0.037–0.043	0.040
Excretory pore to head	0.16 –0.18	0.17



Figures 1–6. *Rusguniella kofoidi* n. sp., from *Nyroca affinis* (Eyton). Fig. 1, dorsal view of head, ×1165; Fig. 2, lateral view of the head, ×1165; Fig. 3, cervical papilla, ×5800; Fig. 4, lateral view of entire worm, ×115; Fig. 5, posterior region of the body showing the characteristic shape of the tail and position of the anus, ×690; Fig. 6, dorsal view of anterior region of the body, ×690.

Host: Nyroca affinis (Eyton).

Location: Under the lining of the gizzard.

Incidence: Four specimens of *Nyroca affinis* taken at Lincoln, Nebraska, in April, 1927, were not infested with *Rusguniella.* A single examination of this host has been made in California.

Distribution: United States: Bay, California.

Rusguniella kofoidi is tentatively assigned to the subgenus *Rusgunioides,* in which lateral alae are absent (Williams, 1929, Univ. Calif. Publ. Zool., 33: 1–12, 7 figs. in text). The possibility exists that lateral alae may appear later in development, but this is not likely. No other members of this genus showing a similar stage of development have been described, so that comparison with better known species is impossible.

These worms were very firmly imbedded in the wall of the gizzard, partly within the mucosa and partly between the mucosa and the heavy layer of connective tissue immediately beneath. The latter had not been penetrated, so far as could be determined, but the mucosa bore scars which indicated clearly the previous wanderings of the parasites within it.

A more complete specific diagnosis of *Rusguniella kofoidi,* as well as a more detailed account of its pathological significance must await the finding of mature individuals.—Owen L. Williams, *Department of Zoology, College of the Pacific, Stockton, Calif.*

A REPARTITION OF THE GENUS *DIPHYLLOBOTHRIUM*

Faust, Campbell, and Kellogg (1929, Amer. Jour. Hyg., 9: 560–583) divided the genus *Diphyllobothrium* into two subgenera on the character of the eggs and outer uterine coils. Mueller (1936, Jour. Parasit., 22: 471–478) pointed out further differences between these subgenera with the comment, "The writer is of the opinion that when the members of the genus *Diphyllobothrium* are more completely known . . . it may be necessary to raise these subdivisions to full generic rank." It is the purpose of this note to point out that at least three different structural types, of generic value, occur in the present genus *Diphyllobothrium,* two of which are now known to have distinctive biological relationships.

Genus 1. Name uncertain. (Fig. 1.) Includes *D. latum* and its relatives. These worms have a small spatulate scolex and long slender neck. Outer uterine coils in form of a rosette. Cirrus and vagina opening together in a common sinus. Uterine pore separate and posterior. Cirrus sac simple, with seminal vesicle not

gs—genital sinus
ov—ovary
sv—seminal vesicle
up—uterine pore
ut—uterus
va—vagina
vu—vulva

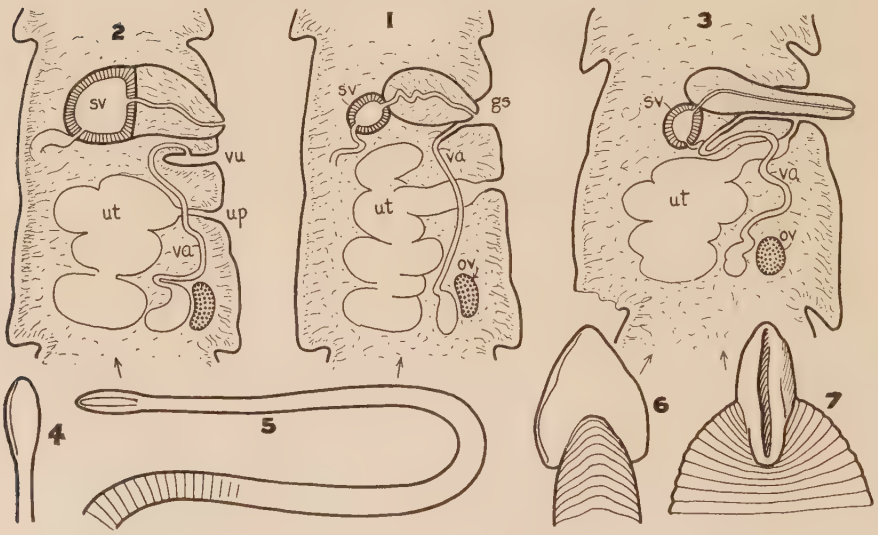


Fig. 1. Showing arrangement of pores and cirrus in the *D. latum* group.
Fig. 2. Arrangement in *Spirometra.*
Fig. 3. Arrangement in Genus 3. All three sagittal sections semidiagrammatic.
Fig. 4. Lateral; Fig. 5. Dorsal, view of scolex, neck, and anterior strobila of *D. latum* group and *Spirometra.*
Fig. 6. Lateral; Fig. 7. Dorsal, view of scolex and anterior strobila of Genus 3.

included but lying separate from and dorsal to the muscular cirrus. Eggs with rounded ends; coracidium swims with a slow rolling motion; first intermediate host a species of *Diaptomus,* second intermediate host a fish.

Note: Older books state that *Cyclops strenuus* is one of the copepod hosts of *D. latum,* but Vogel (1930, Zeitschr. f. wiss. Biol. Abt. F, Zeitsch. f. Parasitenk., 2: 213–223) and Vergeer (1936, Pap. Mich. Acad. Sc., Arts and Let., 21: 715–726) deny this, the latter concluding "the species of *Cyclops* can be regarded only as accidental or abnormal hosts."

Genus 2. Spirometra n. g. (Fig. 2), includes members of the old subgenus *Spirometra* of Faust, Campbell, and Kellogg. These forms have a small spatulate scolex and long slender neck. Anterior uterus in form of a spiral of 2 to 7 closely packed coils. Cirrus and vagina open separately, female pore close in back of male. Uterine pore separate and posterior. Cirrus sac composite, enclosing seminal vesicle. Eggs pointed. Coracidium swimming very rapidly with hooks to the rear. First intermediate host a species of *Cyclops,* second intermediate host a frog, snake, or mammal. Type species: *Spirometra erinacei* (Rudolphi).

The selection of the copepod host in the above two genera is ecologically significant. *Diaptomus* (the first intermediate host of *D. latum*) is a copepod of open lake conditions, where it would be eaten only by fish (the second intermediate host). Hence *Diaptomus* is the ideal copepod for carrying on the life cycle of *D. latum.* Although *Cyclops* occurs in open water, it also thrives under stagnant pool and shoreline conditions which would be fatal to *Diaptomus.* In these situations it is likely to be eaten accidentally by frogs, snakes, and mammals while drinking. These facts are very nicely adapted to the life history requirements of *Spirometra* since it uses these vertebrates as second intermediate hosts.

Genus 3. Name uncertain. Represented by material received from Dr. T. W. M. Cameron, of Canada, taken from an undetermined species of seal. The worm is either *D. lanceolatum* or a species very close to it. There is some question as to the exact identity of *lanceolatum* since, as noted by Stunkard and Schoenborn (1936, Amer. Mus. Novitates, No. 880, pp. 1–9), the descriptions of this form as given by Zschokke (1903), Cholodkovsky (1914), Cooper (1921), and Stunkard's own material all differ in minor features. My specimens agree with Zschokke's rather than Stunkard's material in that the testes lie in a double layer in the medullary portion near the uterus, instead of in a single layer as reported by Stunkard and Schoenborn. The scolex shows glands of the type figured by Fuhrmann for *D. antarcticum,* but not nearly so well developed. The bothria extend to the posterior end of the scolex. Characters of this group are as follows:

Scolex relatively large, cordate, with bothria extending back over anterior proglottids. Neck absent. Strobila expanding abruptly from scolex. Uterus in form of a rosette. Cirrus, vagina, and uterine pore opening together into a common sinus. Cirrus sac as in *D. latum,* with seminal vesicle separate and dorsal. Eggs with rounded ends. Life history relationships for the most part unknown.

It may be added here that an additional undetermined species from the bearded seal, U. S. N. M. Helm. Coll. No. 42595, has been examined and found to belong to Genus 3. Except for the doubling of the genitalia, the arrangement in *Diplogonoporus* is the same as in *D. latum*—Genus 1. *D. cordiceps* from the pelecan also belongs to this group. A form, new for this country, closely resembling *D. mansoni* (*erinacei*), has been reared from apargana from Florida *Natrix,* and on sectioning shown to belong to Genus 2—*Spirometra.* The status of *D. cordatum* is undetermined, but judging from its normal host, the seal, and from published figures of the scolex, it probably belongs to Genus 3.

It is also of great importance to reexamine the type of the genus *Diphyllobothrium—D. stemmacephalum.* The scolex of *stemmacephalum,* as figured by Cobbold (1879), is suggestive of the third genus. But *stemmacephalum* appears to have a long neck, which is more suggestive of the first two genera. However, it seems rather improbable that the same genus of cestode will be found in both the porpoise and land-dwelling mammals. If *D. stemmacephalum* has characters which

definitely set it off generically from *D. latum,* the old name *Dibothriocephalus* will have to be restored for *latum,* which would be an unfortunate, but possibly unavoidable, predicament.

Further studies along the line of research indicated in this note, with a view to disclosing the true relationships of the various species, and settling the questions of nomenclature involved, are now under way.—Justus F. Mueller, *N. Y. State College of Forestry, Syracuse, N. Y.*

COLD-BLOODED VERTEBRATES AS HOSTS FOR *AËDES AEGYPTI* LINN.

A large number of species of warm-blooded vertebrates serve as hosts for *Aëdes aegypti.* No report of this species feeding on cold-blooded animals has come to the attention of the writer. Goeldi (1905, Memorias do Museu Goeldi (Museu Paraense) de Historia Natural e Ethnographia. IV. Para, Brazil) made an unsuccessful attempt to induce females to feed on a lizard.

Nuttall and Shipley (1902, Jour. Hyg., 2: 58–84) report that *Anopheles maculipennis* in captivity, even though hungry, did not feed on a toad (*Bufo vulgaris*) nor on a large earthworm. However, they record an observation of "mosquitoes" sucking the blood of a black terrapin. The females of some species of mosquitoes (*Culex* spp.) feed exclusively on cold-blooded animals. It may be well to note in this connection that Gordon (1922, Ann. Trop. Med. Parasit., 16: 425–439) reports "*Stegomyia calopus* females will bite corpses as long as eighteen hours after death, and will draw blood as long as six hours after death." Temperature in this instance, however, is not necessarily a factor.

The most striking difference between warm- and cold-blooded animals as hosts for blood-meals is that of temperature. All species of mosquitoes, both males and females, habitually ingest substances colder than the blood of birds and mammals. These include juices of plants, particularly nectar and fruit juices, water and other substances at atmospheric temperature. The diet of males of all species, and of females of a few species (*Megarhinus* spp., *Harpagomyia* spp.), is confined to substances colder than blood since the structure of the mouth parts does not permit the insects to pierce the skin of animals.

Howlett (1910, Parasitol. 3: 479–484), concluded from his experiments that warmth is attractive to feeding mosquitoes. The following two experimental observations were made to determine the influence of temperature on the feeding response of *Aëdes aegypti.*

Thirty-five females were released into a cage in which was a cold suspension of red-blood corpuscles. Twenty-three fed within a short time. The remaining ones were unresponsive, but fed immediately on a warm suspension when it was offered.

A preparation of warmed (37°) blood plasma was offered to a cage of forty-two females. Twelve fed within one-half hour. By this time the preparation was cold and there were no mosquitoes on it. A warmed preparation was offered beside the first. Fifteen immediately gathered on the warm preparation and fed. Seventeen were present at one time. The space was crowded and one female left and fed on the cold preparation. This same process was repeated three more times and always with the same result, the mosquitoes responding to the warmed preparation in preference to the cold one. All had fed at the end of the experiment, and nearly all had made their response only to the warmed preparations. The results of this experiment show conclusively that these mosquitoes respond to warmed preparations in preference to cold ones, but it must be noted that they fed readily on the cold preparation when no choice was offered.

It would appear as a result of these considerations that the difference in body temperature alone would not prevent mosquitoes that normally feed on warm-blooded animals from feeding on cold-blooded animals.

Preliminary to an investigation of the effects of the blood of various species of animals on the egg-production of mosquitoes, an attempt was made to feed *Aëdes*

aegypti on two species of cold-blooded animals. Seventy-five female mosquitoes were confined to each of two cages in the laboratory. They were maintained entirely on sugar solution for a period of five days following emergence. They were then deprived of all food and water for 24 hours. At the time of the experiment the temperature was 28° C. and the cages were unprotected from the moderately bright light (daylight) of the room. A frog (*Rana clamitans*) was placed in one cage, and a turtle(*Terrapene carolina*) in the other. Mosquitoes immediately gathered about both of the animals. One female pierced the skin on the back of the frog and took a full blood-meal. Others followed, feeding on the back, legs, and sides. During a period of three hours 23 took medium to full blood-meals and 16 others ingested a recognizable quantity. It is probable that most of the remaining mosquitoes satisfied themselves on the fluid adhering to the skin of the animal. The frog was lightly sprinkled with water at intervals. Mosquitoes gathered over the carapace, head, neck, legs, and sides of the turtle and those in favorable positions on the neck, legs, and sides pierced immediately. During a period of three hours 56 took medium to full blood-meals and 7 others ingested a recognizable quantity. Viable eggs were deposited by both the frog-blood fed and the turtle-blood fed mosquitoes. The larvae from these eggs developed normally and producd normal adults. This experiment demonstrated that *Aëdes aegypti* females under certain laboratory conditions feed readily on frog and turtle, and produce viable eggs. Later experiments have demonstrated that the nutritive value of the blood of these animals is equal to and even superior to that of certain warm-blooded animals (Woke, 1937, in press). The preference of the mosquito for either warm or cold-blooded animals as hosts, however, is not demonstrated by this observation.

The blood of cold-blooded animals, though possibly not preferred to that of warm-blooded animals, may serve under certain conditions to sustain the reproduction of the species in nature. These animals are sluggish and remain motionless for long periods of time. The mosquitoes have access to them in nature and could feed undisturbed.—P. A. Woke, *School of Hygiene and Public Health, Johns Hopkins University.*

COMPARATIVE EFFECTS OF THE BLOOD OF MAN AND OF CANARY ON EGG-PRODUCTION OF *CULEX PIPIENS* LINN.

Introduction: The writer (Woke 1937, in press.) has shown that blood from different species of vertebrates may differ in its effect on the egg-production of *Aëdes aegypti.* Roubaud and Mezger (1934, Bull. Soc. Path. exot., 27: 666–668) fed individuals of two races of *Culex pipiens* on canary and on man, and found that they received more eggs when the mosquitoes fed on canary than when they fed on man. *Culex pipens berbericus* Roub. deposited averages of 187 eggs when fed on canary, and 58 eggs when fed on man. *Culex pipiens autogenicus* Roub. deposited averages of 124 eggs when fed on canary, and 51.5 when fed on man. The quantity of blood ingested by these mosquitoes was not reported.

Objective: *Culex pipiens* Linn. is known to feed on the blood of man and of birds, and possibly feeds on the blood of other species of animals. It is generally believed to prefer birds as hosts. The object of this experiment was to determine whether there exist significant differences in the nutritive value of the blood of man and of canary when fed to *Culex pipiens,* using egg-production as the criterion. The number of eggs produced per milligram of blood ingested served as the basis on which to compare the relative values of the blood of the two species of animals.

Materials and Methods: The methods employed in rearing, handling, and feeding the mosquitoes used in this work were essentially similar to those already described (1937) for the work with *Aëdes aegypti.* The strain used in these experiments was obtained from eggs collected from a stream in the vicinity of Baltimore, Maryland. In the laboratory, eggs were obtained from adults fed on the blood of canary and otherwise maintained on sugar solution and water. The eggs of *Culex pipiens* are laid in a mass on the surface of the water, or in its absence, on very wet material. For the purposes of these experiments it was found satisfactory

to have them deposited on water in a Syracuse watch glass, from which the mass was transferred by means of a wire loop to a glass slide for counting of eggs and to vessels for rearing. For the purposes of counting the eggs, the mass was broken up with a needle into groups of convenient size and counted under a low power binocular microscope. The imagines were fed raisins in addition to sugar solution. The second laboratory generation was used.

Experiments: A preliminary observation preceded and suggested this experiment. Thirty-eight *Culex pipiens* females took blood-meals from man, and deposited 29 masses, totalling 2118 eggs, or an average of 73.0 eggs per mass. At the same time, 39 females took blood-meals from canary, and deposited 22 masses, totalling 4473 eggs, or an average of 203.3 eggs per mass. There did not appear to be sufficient difference in the quantity of blood ingested by the two groups to account for the wide difference in the number of eggs produced. It did appear most probable that the difference might be due to a difference in the nutritive value of the blood of the two species of animals.

An experiment was arranged in which should be determined the quantity of blood ingested and the number of eggs produced by each individual mosquito of a group fed on the blood of man and of another similar group fed on the blood of canary. Detailed individual data of this kind would permit the application of a statistical test for significance of differences observed between the means, if such an analysis appeared to be indicated. Records were obtained of the weight before and after feeding, the number of milligrams of blood ingested, the total number of eggs produced, and the number of eggs produced per milligram of blood ingested, for each individual in each lot. These data are summarized in the following table giving the egg-production of *Culex pipiens* females following ingestion of blood-meals from man and from canary, based on individual records.

	Man	*Canary*
Number of mosquitoes	35	36
Average original weight (milligrams)	2.7	2.7
Total amount of blood ingested (mgs.)	106.3	111.6
Average amount of blood ingested (mgs.)	3.0	3.1
Total number of eggs deposited	4221	9173
Average number of eggs per mosquito	120.6	254.8
Eggs per milligram of blood ingested	39.7	82.2
Ratio (based on eggs per mosquito)	1.0	2.11

The actual difference observed between the means of the egg-production of these two groups is so great as to make it obvious that a very significant difference exists in the nutritive value of human and avian blood for egg-production in *Culex pipiens*. Avian-blood fed mosquitoes produced over twice as many eggs as human-blood fed mosquitoes. The results are so consistent in every case as to leave no doubt that the difference is real. These results substantiate the findings of Roubaud and Mezger (1934) for strains of this species in France. The quantitative treatment eliminates the objection that might be made to the work of these authors, that the difference obtained could have been due to differences in the quantity of blood ingested.

Summary and Conclusions: Experiments were made with a local strain of *Culex pipiens* to determine whether there exists a significant difference in the nutritive value of the blood of man and of canary, using egg-production as the criterion. The number of eggs produced per milligram of blood ingested served as the basis on which to compare the relative values of the blood of the two species of animals. The quantity of blood ingested was determined by weighing the mosquitoes before and after feeding. All the mosquitoes used were produced under similar conditions and were quite uniform. The quantity of blood ingested and the number of eggs produced by each individual mosquito of a group fed on the blood of man and of another similar group fed on the blood of canary was determined. Thirty-five

mosquitoes that fed on the blood of man, and thirty-six mosquitoes that fed on the blood of canary, each produced a mass of eggs, and those produced by the mosquitoes fed on canary blood averaged over twice as many eggs per mass or per milligram of blood ingested as those produced by the mosquitoes fed on the blood of man. It is therefore concluded that *Culex pipiens* produces significantly greater numbers of eggs on the blood of canary than on the blood of man.—P. A. Woke, *School of Hygiene and Public Health, Johns Hopkins University.*

TAENIA SAGINATA—AN UNUSUAL CASE

In checking over the material in the college storeroom the senior author found a quart fruit jar containing tapeworms with a small stoppered bottle enclosed. The worms almost filled the jar. The label gave the following data, "Alik Sida July 16—1911. Removed 10 tapeworms, heads are in the small bottle. Record breaker." Only six heads were found in the small bottle. The material has been determined as *Taenia saginata.*

Other specimens in the college collection were known to have been received through the kindness and generosity of Dr. D. W. Craig, a physician of long residence in Sioux Falls, South Dakota. We, therefore, inquired of him about this material. We learned that Alik Side, given as Sida on the label, had been a patient of Dr. Craig who stated that he well remembers the recovery of ten adult worms and the placing of the ten heads in the small bottle. Four of the heads were undoubtedly removed by someone during the 25 years this material has been in the collection of the college.

The literature at our disposal yields only one other case of multiple infestation with this worm for the United States. Brown (1900, Uni. Med., Galveston, 5: 205–206) reports recovering six adult *T. saginata* from a British sailor. Multiple infestation with this form seems not to be uncommon in other parts of the world. Penfold *et al.* (1936, Med. Jour., Australia, 1: 283–285) report the results of a survey for *T. saginata* infestation in which they found 46 Australians, each harboring one worm; another had two and another, three. Among nineteen Syrian born immigrants, infested upon arrival in Australia, they recovered from 2 to 31 worms each.

We have learned from the relatives that Alik Side, who died in 1919 at the age of 38, was an immigrant born in Syria and it is not unlikely that the infestation reported here was acquired in Syria.—F. G. Meserve, *Sioux Falls College,* and G. Robert Coatney, *Peru State Teachers' College.*

NEW HOST RECORDS FOR *DIPHYLLOBOTHRIUM MANSONOIDES* MUELLER, 1935

In 1933 Mueller (Jour. Parasit. 20: 140–141) reported finding in cats from Syracuse, N. Y., a species of *Diphyllobothrium* which he believed to be new, and in 1935 (Jour. Parasit. 21: 114–121) he described this tapeworm under the name *Diphyllobothrium mansonoides.* In 1936 (Jour. Parasit. 22: 543) Mueller presented notes before the twelfth annual meeting of the American Society of Parasitologists on the life history of the parasite stating he had succeeded in infecting house and field mice with the plerocercoid stage of *D. mansonoides* and that among several small animals infected "the mouse seems to be the normal host, since in it the plerocercoid reaches its greatest size." Although Mueller failed, after an extensive search, to locate animals naturally infested with the plerocercoid, his prediction that the mouse was the usual host of this worm is apparently substantiated by the present note, which contains a record of a natural infection in a cotton mouse with a plerocercoid of *Diphyllobothrium* sp., as well as a new host, the bobcat, for the adult of *D. mansonoides.*

The plerocercoid from the cotton mouse, *Peromyscus gossypinus gossypinus,* was collected by Mr. E. V. Komarek of the Cooperative Quail Study Association, Sherwood Plantation, Thomasville, Ga., December 10, 1936, at Wakulla, Florida.

The specimen was 13.5 cm. long by 0.75 to 1.0 mm. wide, thin and ribbon-like, and with an anterior spindle-shape swelling about 2.5 mm. long and a maximum diameter of about 1.4 mm. This specimen has been stained and mounted, and is now catalogued as U. S. N. M. Helm. Coll. No. 43114.

Included among the parasites collected by Mr. Komarek were several tapeworms (U. S. N. M. Helm. Coll. No. 43115) from a bobcat, *Lynx rufus floridanus,* collected October 13, 1936, at Monticello, Florida, an adjoining locality to the one in which the infected *Peromyscus* was obtained. Fifteen of the tapeworms from the bobcat were *Taenia macrocystis* (Diesing, 1850) and 45 were immature (adults) *Diphyllobothrium* sp. The scolex of the latter checked sufficiently with that of *D. mansonoides* to be considered as belonging to that species, but adults with gravid segments were desired before definitely reporting the bobcat as a host for this parasite. Consequently an examination was made of all the tapeworm material from bobcats in the collection of the U. S. N. M., and two mature specimens of *Diphyllobothrium* (U. S. N. M. Helm. Coll. No. 4407) were found. This material had been collected February 19, 1906, by Hassall and Graybill from a specimen of *Lynx rufus* from North Carolina that had died 11 days after reaching the National Zoological Park at Washington, D. C. A part of one of these specimens had been stained and mounted, and a comparison of this material with the type of *Diphyllobothrium mansonoides* Mueller, 1935, showed them to be identical with that species.

On July 29, 1907, Dr. M. C. Hall collected a *Diphyllobothrium* sp. (U. S. N. M. Helm. Coll. No. 14525) from another bobcat, *Lynx rufus floridanus,* from Vero, Florida, which died in the National Zoological Park, Washington, D. C., 5 months from date that the animal was received. This material consists of three specimens that had become brittle from evaporation of the preservative. A small section of a gravid portion of one of the worms had been mounted, presumably at the time the material was collected, and two "outer" uterine coils, as seen in *Diphyllobothrium mansonoides,* are in evidence; the constriction, however, which sets off the terminal portion of the anterior limb as an ovejector is not conspicuous in the three mounted proglottids. Longitudinal sections were made of a small portion of one of the specimens and from this the genital pores were found to open separately in the same manner as figured by Mueller for *D. mansonoides.* Because of the relationship of the genital pores and the type of uterus this material has been identified by the writer as *D. mansonoides.*

With the above record from bobcats, we now have records of adults of this tapeworm from the house cat from New York; from *Lynx rufus* from North Carolina; two records from *Lynx rufus floridanus* from Florida; and from the house cat from Louisiana. The case from Louisiana was reported by Mueller in 1936 (Jour. Parasit. 22: 471–478) and was based on material collected by Dr. G. Dikmans at Jeanerette in the spring of 1927. This material was reported by Dikmans in 1931 (Jour. Parasit., 18: 47) as a *Diphyllobothrium,* subgenus *Spirometra* Faust, 1929, and not as *D. mansoni* as Mueller has stated.

Dr. Dikmans has informed the writer that this material was from a stray house cat that had forsaken domestication for a life in the "wilds" of Louisiana, doubtlessly feeding on *Peromyscus* instead of the house mouse as had long been the custom of his progenitors. This parasite was not found by Dikmans in "tame" house cats from the same locality. Thus, one might assume that in nature the parasite is primarily one of bobcats and stray house cats, with the plerocercoid stage in *Peromyscus* and possibly other small mammals.

There are a few additional specimens of plerocercoids from mammals from the United States in the collections of the U. S. National Museum. Specimen No. 25230 is a plerocercoid from beneath the skin of a "black fox" from Medford, Wisconsin, collected during the winter of 1922–23 by a Mr. Wimmer; specimen No. 25091 is from beneath the skin of a silver fox from Madison, Wisconsin, collected September 28, 1922, by Dr. F. B. Hadley; and specimen 42295 is from beneath the skin of an otter; *Lutra canadensis ?lataxina,* from Okefinokee Swamp,

Georgia, collected December 30, 1935, by Mr. E. V. Komarek. The above records of plerocercoids, *Diphyllobothrium* sp., are given in hope that they may throw further light on the life history and range of the host of *D. mansonoides.*

It may be noted in this connection that Mueller (1936, Jour. Parasit. 22: 477) has pointed out that cases of Sparganum infestation in man in this country may well be infection with this parasite; this seems to be a logical inference since, so far as known, the plerocercoid stage of *D. mansonoides* develops only in a mammalian host, and the known cases from man are from the South where this tapeworm occurs in native mammals.—ALLEN MCINTOSH, *U. S. Bureau of Animal Industry, Washington, D. C.*

TWO NEW HOST RECORDS FOR THE PROTOZOAN *HAPTOPHRYA MICHIGANENSIS* WOODHEAD

Two species of astomatous ciliates of the genus *Haptophrya* have been described from the digestive tract of certain amphibia: *Haptophrya gigantea* Maupas, 1879, from *Discoglossus pictus,* a toad of western Europe and northern Africa, and *Haptophrya michiganensis* Woodhead, 1928 from the four-toed salamander, *Hemidactylium scutatum.* According to Woodhead (1928, Jour. Parasit., 14: 177–182) examination of several thousand four-toed salamanders from Michigan revealed that 70 per cent were infected with *Haptophrya michiganensis.* One specimen of another salamander, *Ambystoma jeffersonianum,* also was reported as harboring a heavy infection of this protozoan. (A third species, *Haptophrya tritonis* from the Alpine triton was described by Certes in 1879, but was later regarded by Bütschli and others as a doubtful species.) Recently, Rankin (1937, Ecol. Monog., 7: 171–269) has reported several new host records for *Haptophrya* from North Carolina salamanders; one species harboring *Haptophrya gigantea* and five species with infections of *Haptophrya michiganensis.*

In recent examinations of more than one hundred specimens of *Rana sylvatica* LeConte, 1825, collected near Wilmington, Ohio, the writer found infections of *Haptophrya michiganensis* in about 20 per cent of the frogs examined. During the past two years about five dozen salamanders from the same locality, belonging to eight different species, have also been examined for intestinal protozoa. In these *Haptophrya michiganensis* was found but once, in an adult specimen of *Plethodon cinereus* (Green), 1818.

All specimens of this protozoan agree with Woodhead's description except, that they are slightly below the size range given by him and show a more distinct dorso-ventral flattening of the anterior end.

Recently, Woodhead and Kruidenier (1936, Jour. Parasit., 22: 107–108) have made studies on the method of infection of the four-toed salamander by this protozoan. In their experiments they found that the larval salamanders ingested the active organisms and carried them through metamorphosis to the adult stage. They suggested that the breeding habits of this salamander promote such a means of infection, since adult females remain on the nest until the eggs hatch, or even for some time after the emergence of the young salamanders. The authors believe that the protozoa in an active condition are defecated by the adult, and are picked up and swallowed in this condition by the larval salamanders.

It is possible that a similar method of infection may obtain in the case of *Plethodon cinereus,* since this species, like *Hemidactylium* does not deposit its eggs in water. Instead, the eggs when deposited are attached to the roof of crevices in moist logs. The adult female remains with the eggs not only until the young have hatched, but for two or three weeks afterward. It is possible that the protozoa are voided by the female with the fecal matter and are then ingested by the young salamanders, during the time that the brood remains together.

The presence of the protozoan in both *Hemidactylium scutatum* and *Plethodon cinereus* is interesting in view of the similarity of egg laying habits of these two species. However, in the case of *Rana sylvatica* the eggs are deposited in fairly large pools of water and are not supposed to be associated with the adult after

deposition. In view of this it is remarkable that a comparatively high degree of infection should occur in this species.—F. O. Hazard, *Department of Zoology and Entomology, the Ohio State University.*

THE AEROBIC RESYNTHESIS OF GLYCOGEN IN *ASCARIS*

A whole frog (Lesser, 1923, Bioch. Zeit., 140: 577–582) or an isolated vertebrate muscle (Meyerhof, 1920, Pflügers Arch., 185: 11–32) resynthetizes carbohydrate from lactic acid in an aerobic period following an anaerobic one. Similar processes are reported for the free living worms *Tubifex* (Dausend, 1931, Zeit. vergl. Physiol., 14: 557–608) and *Lumbricus* (Davis and Slater, 1928, Bioch. Jour., 22: 338–343). The following experiments were undertaken with *Ascaris lumbricoides* females from the pig in order to study this phase of metabolism in an animal adapted to long periods of anaerobiosis.

The worms were first exposed to 20 hrs. anaerobiosis (hydrogenstream, 1.1 per cent saline, 37° C.), then for varying periods to aerobiosis in open dishes, equally at body temperature and in saline or to corresponding anaerobic periods. The glycogen was determined according to Pflügers' method. The values in table 1 are given in per cent of the fresh worms and in per cent of the value after 20 hrs. anaerobiosis, the latter calculation eliminating better the variations due to different glycogen content in the single experiments. In series I the average glycogen content was higher after two and four hours aerobiosis, than at the beginning of this period (105 resp. 106 per cent of the 20 hrs. value) and the same is true for the six hours aerobic value of series II (104 per cent). After eight hours exposure to air the glycogen level was again lower than at the beginning of the aerobic period (98 per cent), but higher than the value found after a corresponding additional anaerobic period (91 per cent). These two series prove that there is a marked difference between aerobically and anaerobically kept worms. They suggest further that a certain amount of glycogen is synthetized during the first six hours of aerobiosis following twenty hours anaerobiosis. The range of variation, however, was so great that this latter point seemed not sufficiently assured.

Two further series with a greater worm material were therefore performed in order to check the four and eight-hour aerobic value after 20 hrs. anaerobiosis. The variations were smaller. After four hours aerobiosis a value of 102 per cent was found (series III), after eight hours 98 per cent (series IV). These series, therefore, substantiate the view that the ascarids form a small amount of glycogen without receiving food in an aerobic period of four to six hours duration, preceded by an anaerobic period. One hundred grams of worms built in the different series 70–150 mg. of glycogen, the former figure seeming more reliable, since derived from a greater material. If, what is not proved, but likely, glycogen is used during this period at the same rate as during a normal aerobic period, the amount of glycogen rebuilt would be of course somewhat greater. The actually rebuilt glycogen corresponds to about 1/20 to 1/10 of the glycogen consumed during the previous anaerobic period. This is a much smaller figure than in vertebrate muscles, where on an average 4/5 to 5/6 of the lost glycogen is resynthetized. It is very likely that this difference is connected with the ability of *Ascaris* to excrete the end-products of anaerobic metabolism, the excreted parts of course being lost for the resynthesis. Whether the glycogen is synthetized as in vertebrates from lactic acid or from the chief end-product of the *Ascaris* carbohydrate metabolism, lower fatty acids, cannot be decided at the present time. It is likely that the process described here can also go on under natural conditions. *Ascaris* is doubtless living usually under anaerobic conditions, but sometimes it has access to greater or smaller amounts of oxygen, as demonstrated by the finding of this gas in the intestinal gases of the pig by Long and Fenger (1917, Jour. Chem. Soc., 39: 1278–1286) and by Brand and Weise (1932, Zeit. vergl. Physiol., 18: 338–346).—Th. v. Brand, *Helminthological Department, School of Hygiene and Public Health, Johns Hopkins University.*

TABLE 1.—*Glycogen resynthesis in* Ascaris lumbricoides *females in an aerobic period following an anaerobic one at 37° C.*

	Series I	Series II	Series III	Series IV
Beginning :				
Total weight of worms (gms.)	569.1	586.1		
Glycogen gms. per 100 gms. of worms.	4.83 ± 0.25 (3.71–6.40)	4.26 ± 0.15 (3.36–5.08)		
Glycogen % of 20 hrs. value	149 ± 6 (120–218)	134 ± 4 (111–162)		
20 hrs. anaerobiosis :				
Total weight of worms (gms.)	552.5	581.9	1584.8	1705.4
Glycogen gms. per 100 gms. of worms.	3.31 ± 0.20 (2.38–4.95)	3.25 ± 0.10 (2.86–3.91)	3.19 ± 0.27 (1.49–4.30)	3.68 ± 0.42 (1.40–6.02)
Glycogen % of 20 hrs. value	100	100	100	100
24 hrs. (Ser. I) and 28 hrs. (Ser. II) anaerobiosis :				
Total weight of worms (gms.)	442.8*	586.7		
Glycogen gms. per 100 gms. of worms.	3.17 ± 0.22 (2.32–4.84)	2.98 ± 0.19 (1.95–4.24)		
Glycogen % of 20 hrs. value	95 ± 3 (82–111)	91 ± 3 (68–108)		
20 hrs. anaerobiosis + 2 hrs. aerobiosis :				
Total weight of worms (gms.)	564.7			
Glycogen gms. per 100 gms. of worms.	3.45 ± 0.24 (2.70–5.40)			
Glycogen % of 20 hrs. value	105 ± 4 (91–128)			
20 hrs. anaerobiosis + 4 hrs. aerobiosis :				
Total weight of worms (gms.)	560.2	.....	1575.2	
Glycogen gms. per 100 gms. of worms.	3.46 ± 0.17 (2.52–4.77)	.....	3.26 ± 0.26 (1.53–4.64)	
Glycogen % of 20 hrs. value	106 ± 3 (90–132)	.....	102 ± 0.8 (98–108)	
20 hrs. anaerobiosis + 6 hrs. aerobiosis :				
Total weight of worms (gms.)	.....	512.5**		
Glycogen gms. per 100 gms. of worms.	.....	3.42 ± 0.16 (2.64–4.24)		
Glycogen % of 20 hrs. value	.....	104 ± 3 (89–120)		
20 hrs. anaerobiosis + 8 hrs. aerobiosis :				
Total weight of worms (gms.)	.....	572.6	.....	1742.1
Glycogen gms. per 100 gms. of worms.	.....	3.21 ± 0.16 (2.30–4.10)	.....	3.54 ± 0.38 (1.45–5.55)
Glycogen % of 20 hrs. value	.....	98 ± 3 (79–112)	.....	98 ± 1.5 (91–109)

The mean values are derived from 12 experiments each (*9 experiments, **11 experiments). Figures in parenthesis are the extremes. Each lot of Series I and II contained 10 worms in the single experiment, in Series III and IV, 30–50.

A PROTOZOOLOGICAL SURVEY OF 35 GUESTS AND 18 EMPLOYEES OF A HOME FOR THE AGED

In a recent survey of 1060 college freshmen (Wenrich, Stabler and Arnett, 1935, Am. Jour. Trop. Med., 15: 331–345) the data indicated that students from homes in Philadelphia had a higher incidence of infection with *Endamoeba histolytica* than those living in other parts of Pennsylvania or in New Jersey. It was therefore thought desirable to get as much additional information as possible in regard to these indications. Advantage was therefore taken of an opportunity to make a protozoological survey of the inhabitants of an Old Ladies' Home in Philadelphia. We did not secure as full cooperation of the guests as was expected, so that only 35 of them provided fecal samples for examination. It was also realized that an evaluation of the data might be aided by a survey of the employees, especially of the food handlers. Eighteen of these were examined, 9 women and 9 men. The examination of a single normally-passed stool from each person was carried out in the manner described for the survey of college students.

It is realized that the small numbers dealt with prevent the data from having the value that larger numbers would have, but it was thought worth while to put the results on record. The accompanying table gives the numerical data.

	Guests (35)		Employees (18)		Totals (53)	
	Nos.	%	Nos.	%	Nos.	%
Blastocystis	29	82.9	13	72.2	42	79.2
Some Protozoa	26	74.3	12	66.7	38	71.7
Endolimax nana	21	60.0	4	22.2	25	47.2
Endamoeba coli	7	20.0	3	16.7	10	18.9
Chilomastix mesnili	6	17.1	..	...	6	11.3
Endamoeba histolytica	3	8.6	3	16.7	6	11.3
Iodamoeba bütschlii	2	5.7	..	...	2	3.8
Giardia lamblia	2	5.7	2	11.1	4	7.6
Enteromonas hominis	2	5.7	..	...	2	3.8
Trichomonas hominis	1	2.9	..	...	1	1.9

It will be noted that in general the percentages are rather high, and especially so for *Endolimax* and *Chilomastix*. Higher incidences would be expected of an institutionalized group, but since incidence of protozoal infections is thought by some authorities to decrease with increasing age, these two tendencies might be expected to operate against each other.

The range of ages for the guests was 63 to 91 years with an average of 72.2. Eight out of 11, or 72.7 per cent, of those with ages from 63 to 72 harbored one or more protozoa, giving an average number of infections of 1.3 per person; 11 out of 15, or 73.3 per cent, of those with ages from 73 to 82 had one or more protozoa, making an average of 1.1 infections per person; 7 out of 9, or 77.7 per cent, of those with ages from 83 to 91 carried one or more protozoa, giving an average of 1.4 infections per person.

In regard to length of residence it was found that 9 out of 13, or 69.2 per cent, of guests who had been in the institution for 11 to 32 years harbored one or more protozoa, giving an average of 1.0 infection per person; 9 out of 11, or 81.8 per cent, who had been resident for 6 to 8 years carried one or more protozoa and the average was 1.5 infections per person; 8 out of 11, or 72.7 per cent, among those resident for 3 to 5 years had one or more protozoa giving an average of 1.4 infections per person. The three guests who harbored *Endamoeba histolytica* were 70, 78 and 85 years old and had been resident for 8, 6 and 13 years, respectively. On account of the small numbers dealt with the differences indicated above seem too small to be of significance.

The ages of the 18 employees ranged from 19 to 60 years, with an average of 36.9 years. Their periods of employment varied from one month to 27 years. Of the three persons harboring *Endamoeba histolytica,* one had been at the institution 11 years, one 3 years and one about one month.

It may be noted that all 3 of the *E. histolytica* infections among employees and 2 of the 3 among guests were of the small race, sometimes referred to as *E. hartmanni:* none had diarrhea or other symptoms of amebic dysentery. The guest harboring the regular-sized race was afflicted with arthritis. One of the three carriers among the employees had been operated on for appendicitis; none of the other four carriers recorded any significant symptomatic history.

In comparison with the college students previously surveyed, these groups of institutionalized persons have higher incidences of all protozoa except *Giardia,* in harmony with the well-established tendency for higher incidence to exist among residents of such institutions. On the other hand, there is little evidence of increased incidences due to increased years of residence, or for a decrease in relation to advancing age. There seems to be no way of determining whether or not the food-handlers have contributed significantly to the infections among the guests.—D. H. Wenrich and John H. Arnett, *University of Pennsylvania.*

AMERICAN SOCIETY OF PARASITOLOGISTS

Twelfth Annual Meeting, Atlantic City, N. J.

December 29, 30 and 31, 1936*

Minutes of Twelfth Annual Business Meeting

The Twelfth Annual Business Meeting was called to order by President Hegner at 1:30 P. M. on Wednesday, December 30th, 1936, at the Hermann Restaurant, Atlantic City, N. J., following the annual luncheon of the Society.

I. Reports of Officers

The report of the Secretary, certified as correct by the auditing committee of the Council, was accepted and ordered filed.

The report of the Treasurer, certified as correct by the auditing committee, was accepted and placed on file. Since Justin Andrews had completed two terms as Treasurer and declined a further nomination for the office, the Secretary moved a vote of appreciation and thanks to him for his four years of able, loyal and devoted service as Treasurer of the Society. The motion was passed unanimously.

The report of the Custodian of the Permanent Secretarial Fund, approved as correct by the auditing committee, was presented by Norman R. Stoll. The report was accepted and a vote of thanks extended to the Custodian.

II. Reports of Representatives of the Society

Report of the representatives of the American Society of Parasitologists on the Council of the A. A. A. S. was the next order of business. No written report was submitted. An oral report was made by George R. La Rue, who listed the items of business which had been considered by the Council of the A. A. A. S. during the early part of the meeting. Since the Council was to hold additional sessions, the tentative report was accepted.

The report of the representatives of the Society on the Council of the U. A. B. S. was presented by D. H. Wenrich. In conformity with instructions voted at the annual meeting of Council, D. H. Wenrich moved the following resolution: "Recognizing the value of Biological Abstracts for all students and investigators in the field of Biology, The American Society of Parasitologists wishes to express its appreciation of the service and to take substantial action to insure the continuation of the publication. Since a large percentage of the older members of the Society are members of other societies which support the Abstracts, and since many of the younger members are not in a financial position to assume further obligation, the Society feels that it would be unwise to impose a blanket assessment. The funds of the Society will not justify an appropriation from the treasury and accordingly the treasurer is authorized to request from members a voluntary subscription of $1.00, to be turned over to Biological Abstracts as an expression of our interest and support." On motion, duly seconded, the report of the representatives of the Society on the Council of the U. A. B. S. was accepted. The resolution which they offered was adopted without a dissenting vote.

III. Reports of Committees

The report of the committee on Necrology was presented by the Editor. Since the obituary notices had already been published in the Journal of Parasitology, the report was given for information only and no action was taken.

* Program report has already appeared in *Science,* Feb. 5, 1937.

The report of the committee on Terminology was presented by Marshall Hertig. The two statements submitted by the committee since its appointment were discussed and it was voted that both be accepted and published in the JOURNAL OF PARASITOLOGY as supplements to the record of the Twelfth Annual Meeting.

The report of the Editorial Committee, certified as correct by the auditing committee of Council, was submitted by W. W. Cort. The report was accepted. The Secretary then presented the recommendation of Council that beginning with Volume 24, (1938) the price of the JOURNAL OF PARASITOLOGY be increased from $4.00 to $5.00, except to members of the American Society of Parasitologists who are to receive it as a membership privilege at the former price of $4.00. The motion was passed unanimously.

IV. NEW BUSINESS

The Secretary presented a letter from Doctor Ivey Lewis inviting the American Society of Parasitologists to become affiliated with the Division of Biology and Agriculture of the National Research Council, as a member of Group VIII in that Division. He reported that the Council had recommended favorable action on this invitation and moved that the Society accept it. After the motion had been passed, the Secretary requested permission to place an additional motion before the Society and when this was granted he stated that it would be appropriate to have Robert Hegner serve as the first representative of the Society on the Division of Biology and Agriculture of the National Research Council. Such a motion, made and seconded, was put by the Secretary and Doctor Hegner was unanimously elected to represent the Society on the National Research Council until July 1st, 1940.

The Secretary presented a letter from Doctor A. M. Banta, Secretary of the American Society of Naturalists, requesting that the American Society of Parasitologists join with the American Society of Naturalists, the American Society of Zoologists, the Botanical Society of America and the Genetics Society of America in sponsoring the Naturalists' Symposium. The Secretary stated that Council had considered the matter and recommended to the Society the acceptance of this invitation. It was moved, seconded and passed that the Society cooperate with the other biological groups in sponsoring the Naturalists' Symposium. The Secretary reported, for information, that the Council had voted the appropriation of $10.00 toward the Biologists' Smoker for 1937. The Biologists' Smoker is sponsored by the several biological societies.

The Secretary presented a letter from Charles Camsell, Chairman of the committee to arrange for the 1938 summer meeting of the A. A. A. S. in Ottawa, Canada, extending an invitation to the American Society of Parasitologists to join in that meeting. The Society voted to approve the recommendation of Council that it participate in the meeting and that Thomas W. M. Cameron be authorized to arrange for the presentation of papers in parasitology, under the name of the Society, insofar as such cooperation could be accomplished without expense.

For information of the Society, the Secretary reported the action of the Council concerning the change in the financial responsibility for the Journal account. Hereafter the Treasurer of the Society shall assume the responsibilities formerly held by the Journal Treasurer and will keep the accounts and pay the bills incidental to the publication of the JOURNAL OF PARASITOLOGY.

The Secretary reported the election by Council of fifteen new members to the Society and the election of a new editorial committee to assume responsibility for publication of the Journal on January 1st, 1938. The new editorial committee is composed of Norman R. Stoll, Chairman, William A. Riley and William H. Taliaferro. During the course of next year, the present editorial committee will accept papers until Volume 23 is completed, but manuscripts for the ensuing volume will be transmitted to the new editorial committee which will be responsible for Volume 24. The Secretary reported the election of H. E. Ewing, H. J. Van Cleave and J. F. Kessel as members of the Editorial Board to succeed F. C. Bishopp, G. R. La Rue and D. H. Wenrich. He announced that for the year 1937 the Council had

voted the election of E. R. Becker and E. C. Faust as representatives of the Society on the Council of the American Association for the Advancement of Science and the election of C. G. Huff and E. W. Price as representatives of the Society on the Council of the Union of American Biological Societies.

According to the by-laws, the Council of the Society shall make nominations for officers to the annual meeting and the following list of nominees was presented: President, for one year, George R. La Rue; Vice-President, for one year, David H. Wenrich; Secretary, for two years, H. W. Stunkard; Treasurer, for two years, Gilbert F. Otto. Members of the Council, for four years, Justin Andrews and Norman R. Stoll. The President requested additional nominations for these offices and when no further nominations were offered, a motion was made that the nominations be closed and the Secretary be instructed to cast one ballot for the slate presented by Council. The motion was unanimously passed. The election of D. H. Wenrich to the Vice-Presidency created a vacancy on the Council and Earl C. O'Roke was elected to fill the unexpired term of D. H. Wenrich as councillor.

The final item of business concerned the next meeting place of the Society. It was voted that the Society meet with the A. A. A. S. in December, 1937, at Indianapolis.

Minutes of the Twenty-fifth Council Meeting

The twenty-fifth meeting of the Council of the American Society of Parasitologists was held at the Ambassador Hotel, Atlantic City, N. J. The meeting convened at 2:30 P. M., December 28th, 1936, with President Robert Hegner in the chair. There were present: R. Hegner, J. Andrews, H. W. Stunkard, J. E. Ackert, W. W. Cort, E. B. Cram, N. R. Stoll and D. H. Wenrich. The secretary presented letters from the Vice-President, W. B. Herms, and from Council Members J. F. Kessel, H. E. Meleney and W. A. Sawyer, expressing regret at their absence and good wishes to the Society.

The Minutes of the twenty-fourth Council meeting had been circulated to Council and after approval they were published in the JOURNAL OF PARASITOLOGY, Volume 22, No. 3.

The President appointed E. B. Cram and D. H. Wenrich as the auditing committee of the Council to examine and report on financial statements submitted by the officers of the Society.

The report of the secretary was accepted and approved, subject to audit.

The report of the treasurer was accepted and approved, subject to audit. The treasurer reported that the Department of Protozoology, Johns Hopkins University School of Hygiene, had provided secretarial assistance during the year and a vote of thanks was expressed to Professor Hegner for this service.

The report of the custodian of the Princeton Secretarial Fund was accepted and approved, subject to audit.

The report of representatives of the American Society of Parasitologists on the Council of the Union of American Biological Societies was presented by D. H. Wenrich and the Council voted that a resolution be presented to the annual meeting by representatives of the Society on the Council of the Union. It was the opinion of Council that it would be unwise to assess the membership of the Society for the support of Biological Abstracts, since many of the members were young investigators and the older ones hold membership in other biological societies which do support the Abstracts. It seemed wisest to ask members of the Society for voluntary contributions in support of Biological Abstracts.

In the absence of E. C. Faust and G. R. La Rue, there was no report to the Council by the Society representatives on the Council of the American Association for the Advancement of Science.

The report of the committee on Necrology was presented by W. W. Cort. Necrology notices had been published in the December Number of the JOURNAL OF PARASITOLOGY.

The report of the committee on Terminology was presented by the secretary. After discussion, it was moved that the Council recommend to the annual meeting the acceptance and publication of the reports of the committee on Terminology as a part of the Minutes of the Twelfth Annual Business Meeting of the Society.

The report of the Editorial Committee was presented by W. W. Cort and approved, subject to audit. The Editorial Committee recommended that in view of the increase in size of the Journal, beginning with Volume 24 (1938), the price of the Journal be increased from $4.00 to $5.00 for non-member subscribers. It was believed that the increase in price would not result in loss of subscriptions, and that it would give an incentive for increased membership in the Society. The Council voted to recommend to the annual meeting that this action be taken.

The secretary read a communication from Professor Ivey F. Lewis, inviting the American Society of Parasitologists to become affiliated with the Division of Biology and Agriculture of the National Research Council, as a member of Group VIII in that Division. Doctor Lewis stated that each affiliated Society appoints a representative to serve for a period of three years and that in each group of the Division of Biology and Agriculture, one representative is executive member and represents the group at the meetings of the Division. He stated, "If the American Society of Parasitologists should accept membership, its representative will be the executive member for the period July 1st, 1943, to June 30th, 1946." It was moved by W. W. Cort, seconded by D. H. Wenrich, that the Society recommend to the annual meeting the acceptance of the invitation to become affiliated with the National Research Council and that if the Society approves the recommendation that our representative be elected for a period of three and one-half years, that is, until July 1st, 1940. The motion was unanimously passed.

The secretary presented a communication from Doctor A. M. Banta, secretary of the American Society of Naturalists, requesting that the American Society of Parasitologists join with the American Society of Naturalists, American Society of Zoologists, the Botanical Society of America and the Genetics Society of America in sponsoring the Naturalists' Symposium. Doctor Banta also wrote that the American Society of Naturalists arranges for the Biologists' Smoker and requested that the American Society of Parasitologists join other biological societies which in recent years have made contributions toward the expenses of the Smoker. Council voted to recommend to the annual meeting that the Society join in sponsoring the Naturalists' Symposium and voted the appropriation of $10.00 toward the expenses of the Biologists' Smoker for 1937.

The secretary presented a letter from Charles Camsell, Chairman of the Committee, to arrange for the 1938 summer meeting of the American Association for the Advancement of Science in Ottawa, Canada, extending an invitation to the American Society of Parasitologists to join in that meeting. The Council voted that the Society accept the invitation to join in the Ottawa meeting, summer of 1938, and elected Thomas W. M. Cameron as the representative of the Society to confer with the Ottawa committee. Doctor Cameron was authorized to arrange for the presentation of papers in parasitology under the name of the Society insofar as such cooperation could be accomplished without expense.

The secretary then transmitted a letter from Doctor J. R. Schram concerning the present status of Biological Abstracts and requesting the Society to take any appropriate action looking toward the support of Biological Abstracts. He suggested that the Society adopt the procedure which has been followed by the American Society of Zoologists in which each member is assessed for the support of publication. The correspondence with Doctor Schramm was referred to D. H. Wenrich for consideration and for report at the annual business meeting.

It was moved by N. R. Stoll: "that the office of Journal Treasurer, heretofore by Council vote (requested and approved unanimously by Council in a mail vote, circular letter dated June 15, 1932, and recorded in the 20th Council meeting of the Society, September 24th, 1932) a part of the office of Chairman of the Editorial Committee of the JOURNAL OF PARASITOLOGY, hereafter be separated from that of

the Chairman of the Editorial Committee and be combined with the office of Treasurer of the Society." It was held that in the long run the Journal would get better editorial supervision if the Chairman of the Editorial Committee were not burdened with the task of handling subscriptions, keeping accounts and paying bills incidental to the publication of the JOURNAL OF PARASITOLOGY. Furthermore, it seemed appropriate that all of the financial transactions of the Society should be handled in a single office with resulting simplification and with increased efficiency. After discussion the motion was unanimously passed. With this change in the status of the Treasurer's office, it was decided that the Treasurer should attend the annual Council meetings and it was voted that hereafter a sum of $50.00 be voted annually to the Treasurer for the expense involved. In previous years there had been no regular stipend voted to the Treasurer and on occasion, when he attended the annual meeting, an expense item was voted to him.

The usual $50.00 was voted to the secretary in connection with the attendance at the annual meeting and $100.00 for office expenses during the course of the year.

Fifteen new members were elected to the Society. Fourteen of these persons were elected as regular members and Mrs. Wanda S. Hunter was elected as a non-subscribing member, the Council approving a motion that where a second membership is taken in the same immediate family, the second member may join on the payment of $1.00, but without Journal privilege.

J. E. Ackert, Chairman of the committee appointed at the last annual meeting to recommend to Council nominees for the new editorial committee and officers, reported that members of the committee had unanimously agreed to invite Norman R. Stoll to accept the position of Chairman of the Editorial Committee for the five year term beginning January, 1938, and that W. A. Riley and W. H. Taliaferro be invited to continue as the other members of the Editorial Committee. For the Committee, J. E. Ackert moved the election of these nominees and the motion was unanimously passed.

The Council, as a committee, voted to recommend to the annual meeting the following nominations: For President, one year, George R. La Rue; Vice-President, one year, David H. Wenrich; Secretary, for two years, H. W. Stunkard; Treasurer, for two years, Gilbert F. Otto. Members of the Council, for four years, Justin Andrews and Norman R. Stoll; to fill unexpired term of Dr. Wenrich, E. C. O'Roke. The Council voted election of the following members of the Editorial Board for the ensuing four year term: H. E. Ewing, H. J. Van Cleave and J. F. Kessel. Council also voted the election of E. R. Becker and E. C. Faust as representatives of the Society on the Council of the American Association for the Advancement of Science. Furthermore, Council voted the election of C. G. Huff and E. W. Price as representatives of the Society on the Council of the Union of American Biological Societies.

It was moved to recommend to the annual meeting that the Society meet next year with the American Association for the Advancement of Science at Indianapolis.

Council adjourned at 6:00 o'clock P. M.

Respectfully submitted,

HORACE W. STUNKARD, *Secretary*

SUPPLEMENT TO THE REPORT OF THE TWELFTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF PARASITOLOGISTS

Report of the Committee on Terminology

Infection vs. *Infestation; "Host-Parasite" Specificity*

At the 1933 meeting of the American Society of Parasitologists in Cambridge, certain matters of terminology were brought up which led to the appointment of a Committee on Terminology. This is its first report, submitted at the Pittsburgh meeting, December, 1934. It is obvious that the functions of any such committee can be no more than informative and advisory and that any attempts at legislation are unwarranted. It is on this basis that the Committee has prepared this report.

Infection vs. *Infestation*

The discussion at the Cambridge meeting reflected the confusion in usage by medical men and parasitologists of the words *infect, infest* and their derivatives. Neither current literature, textbooks, dictionaries nor one's colleagues provide any consistent guide to the "correct" usage of these terms.

The use of *infect* and *infection* (from the Latin *infectus,* past participle of *inficere,* to put or dip into, stain) in connection with disease, long antedated the knowledge of pathogenic microorganisms. Their use implied tainting with morbid matter, contamination with noxious effluvia, vapors, miasmata and the like. There was thus the connotation of invisible and internal agents. *Infest* and *infestation* (from the Latin *infestus,* disturbed, hostile, troublesome) were, and by the laity are, restricted to obvious, external agents which trouble, molest or harass by reason of numbers, frequency or persistence, such as pirates, thieves, rats and fleas.

During the latter part of the nineteenth century *infection* was generally used in connection with pathological processes of all sorts, whether caused by bacteria, protozoa or helminths. With increase in knowledge of these organisms, there was an attempt to limit *infection* to those organisms, such as bacteria and protozoa, capable of indefinite multiplication within the host, while *infestation* was proposed for those which do not so multiply, which would include helminths and insects. In practice, most of the confusion in usage is in connection with helminths.

Whatever may have been the merits of this distinction at the time it was proposed, it seems at this distance to have been a meaning arbitrarily read into two terms already widely used, and that this meaning had no firm foundation in either etymology or usage. In any event, the term *infestation* has not become well established. In none of a number of modern dictionaries consulted has this term acquired any meaning in connection with internal parasites. Certainly there is no consistent use of the term in several recently published helminthological texts, where one would expect to find *infestation* accurately defined and meticulously used, if it is considered to have validity in connection with helminths. Of several texts examined at random, only one gives the distinction between *infection* and *infestation.* This and one other use the term *infestation* consistently for helminths, while three others use the term *infection* throughout. This lack of unanimity among helminthologists may be interpreted as a tendency toward abandoning the term *infestation.*

The terms *infection* and *infestation* refer to processes undergone and effects produced by parasites, rather than to the nature of systematic position of the organisms themselves. In the invasion of the host and subsequent establishment of parasites the phenomena involved in resistance, susceptibility, dosage, host-specificity, virulence and the like, exhibit so many fundamental similarities for the various groups of organisms concerned, that it seems awkward to use first one and then

another term for the same process or condition. This awkwardness is reflected by the fact that those who speak of helminthic *infestations* nevertheless use the term *infective* for the stage of the parasite which accomplishes the invasion and causes the *infestation.* This inherent inconsistency is doubtless responsible for much of the confusion, coupled with the fact that there are no sharp differences in the processes and conditions termed *infections* and *infestations.*

We believe that *infest* and *infestation* ought to revert to their original use in connection with external, and in most cases visible, agents. There would be retained the long established use of these terms in connection with most insects in speaking of such conditions as dogs *infested* with fleas, *infestations* of mosquitoes and the like. On the other hand, we believe the terms *infect* and *infection* properly applicable wherever the parasite invades and establishes itself within the body of the host, including, in this sense, the gastro-intestinal tract. This would apply then, not only to bacteria and protozoa, but also to helminths and those insects, such as the bot and warble flies, which become internal parasites. Lines are difficult to draw sharply and it seems neither necessary nor desirable to attempt it. For conditions which do not lie clearly in either category, such as those involving the Sarcoptoid mites, maggots in ulcers, external orifices, etc., the terminology could well be left to the judgment and taste of the author.

We fail to see any reason for continuing the use of the term *infestation* as applied to internal parasites and believe that the present confusion will disappear only it its use be discontinued. It is realized that a writer's tastes and convictions will continue to dictate his usage in the matter, but we believe the burden of justification may well be placed upon those who continue such use of *infestation.*

Host-Specificity; Host-Parasite Specificity

Apparently *host-parasite specificity* has been used loosely or as a slip of the pen when *host-specificity* was intended. It is obvious that there may be *host-specificity* on the part of a given parasite, but it can hardly be maintained that the converse exists, namely *parasite-specificity* on the part of a given host.

Marshall Hertig
W. H. Taliaferro
Benjamin Schwartz

The Terms *Symbiosis, Symbiont* and *Symbiote*

The term *symbiosis* (from the Greek *sumbiosis,* living together) has two chief meanings as employed in biological literature. By some it is used as a general term applied to all cases where dissimilar organisms live together. It is very commonly restricted, however, to the relationship between organisms which live in close and mutually advantageous association.

According to Nuttall (1923), Meyer (1925), Cleveland (1926) and Hegner (1929), the term *symbiosis* was originally proposed by de Bary in "Die Erscheinung der Symbiose" (Strassburg, 1879), to designate the phenomenon exemplified by the mutually beneficial association of fungi and algae in the formation of lichens. An examination of this paper, however, shows that these authors have misinterpreted de Bary.

The 1879 paper, a pamphlet of about thirty pages, is the published form of an address delivered at a general meeting of German Naturalists and Physicians at Cassel shortly prior to October, 1878. The term *symbiosis* was introduced in the first paragraph of the text (p. 5) in which de Bary stated that in seeking a subject for his address, his preoccupation at that time with a peculiar association of two plants led him to undertake "eine Betrachtung der Erscheinungen des Zusammenlebens ungleichnamiger Organismen, der Symbiose, wie man kurz und allgemein sagen kann." De Bary made it quite clear throughout that he was using *symbiosis* as a general term and that he included specifically all degrees of *parasitism, commensalism* and *mutualism,* as the following quotations show: (p. 6) "Die bekannteste

und exquisiteste Erscheinung der Symbiose ist der *vollständige Parasitismus.*" This was followed by a discussion of various types of parasitism. On pages 5, 6 and 9 de Bary referred to van Beneden's book on animal parasites (1876) and cited the latter's definitions of *commensalism* and *mutualism.* It may be noted that van Beneden proposed the term *mutualism* for the relationship, supposed by him to be reciprocally advantageous, in which organisms, such as the Mallophaga, in feeding on epidermal scales, excretions, feather debris and the like, "care for the toilet of their hosts." De Bary, in seeking among plants parallels for van Beneden's *mutualists,* mentioned *epiphytes* such as orchids, mosses, etc. In discussing various other associations of plants, particularly the lichens, de Bary observed that these did not fall readily into then existing categories, but finally classed them as examples of *mutualism.** The meaning which de Bary's discussion and illustrations gave to the term *symbiosis* is summed up in the following sentences (p. 21): "Parasitismus, Mutualismus, Lichenismus v. s. v. sind eben jeweils bestimente Specialfalle jener allgemeinen Associationseinrichtung, für welche der vorangestellte Ausdruck Symbiose als Collectivbezeichnung dienen mag. Will man unter dieser Hauptkategorien unterscheiden, so dürften sich deren zwei herausstellen, die *antagonistische* mit gegenseitiger Bekampfung und die in weiterem Sinne *mutualistische* mit gegenseitiger Förderung der Symbionten."

It is thus seen that while de Bary in the 1879 pamphlet was very largely concerned with the associations of fungi and algae in the formation of lichens and with other close associations in which mutual benefits accrued to the members thereof, he applied to them van Beneden's term *mutualism* and treated them merely as one of several relationships characterizing the living together of unlike organisms, for which *symbiosis* was proposed as a general term.

The term *symbiosis* was defined and used in the same broad sense in de Bary's work, "Die Vergleichenden Morphologie und Biologie der Pilze, Mycetozoen und Bacterien" (1884), *e.g.,* in sections 99–101 and 103.

The almost casual way in which the term was introduced in the 1879 symbiosis pamphlet, together with its use in the title, might give one the impression that it had been used previously in biological literature. Oskar Hertwig (1883) made it clear that it was de Bary who proposed the term, and the writer of this report has found no reference to it earlier than the symbiosis address. The term apparently does not occur at all in de Bary's book, "Morphologie und Physiologie der Pilzen, Flechten und Mycetozoen" (1866), which is often for convenience referred to as the first edition of the 1884 book, where *symbiosis* has the status of an established term.

It has not been determined just how and when the originally consistent usage of the term *symbiosis* gave way to the confusion which has marked its later years. An illustration of change from broad to narrow usage in the work of one author is found iln the case of Oskar Hertwig. In 1883 he read a paper, "Die Symbiose oder das Genossenschaftsleben im Thierreich," before the same scientific body de Bary had addressed five years previously, when Hertwig himself had been present. He referred to de Bary's address and stated that he had chosen the same theme to enlarge upon with material from the animal world. He used the term *symbiosis* in precisely the same broad sense as de Bary, cited with approval van Beneden's term *mutualism,* and specifically included *parasitism* under *symbiosis.* However, in his textbook, "Allgemeine Biologie" (1906), on page 392 he stated, in referring to associations with mutual benefit, that "such a relationship the botanist de Bary has named *symbiosis,*" which we have just shown above to be a misinterpretation of de Bary. On pages 395–396 Hertwig distinguished *parasitism* from *symbiosis.*

* Am ersten wurde für die in Rede stehenden Formen [lichens and various other plant associations] wohl noch die Bezeichnung *Mutualisten* angewendet werden können, und zwar dann, wenn wir zugeben, dass sich, wie bei den entsprechenden Thieren, Cast und Quartiergeber gegenseitig irgendwie nützen, Dienste leisten."—De Bary (1879, p. 19).

This illustration perhaps gives some indication of the process by which the term has been narrowed. Apparently the original definition and usage of *symbiosis* was overshadowed by its association from the very beginning with numerous and striking instances of mutualism.

Nuttall (1923) called attention to the fact that bacteriologists constantly misapply the term *symbiosis* to bacteria grown in mixed culture. The term is also used by them in cases where organisms grow better in association than separately, and also in cases where a given pathological effect is produced only by the simultaneous action of two or more separate organisms. In none of these cases is the association invariable or necessary to the life of any of the organisms concerned nor is there close bodily contact. The use of the term *symbiosis* in these cases seems unfortunate. A term such as *association* would be both adequate and appropriate.

The terms *symbiont* or *symbiote* are applied to the members of the symbiotic association and may properly be used for either member, though it has become the custom to refer to the smaller as the *symbiont* or *symbiote* and to the larger as the *host.* Usage in this respect would seem to be wholly a matter of convenience and taste. The precise meaning of these terms depends, of course, upon the meaning of *symbiosis* in any given case.

It may be pointed out that in the literature of the intracellular symbionts of insects, which comprise a large number of unnamed and unclassified microorganisms, there is a tendency to consider *symbiont* as possessing systematic connotations. For example, one author has objected to the designation of the rickettsia-like organisms of the bedbug as symbionts, maintaining that they can not be rickettsiae and symbionts at the same time. It is obvious that *symbiont* connotes only a mode of life.

There is some disagreement in the literature as to which of the two terms, *symbiont* or *symbiote,* is the proper one. *Symbiont* is the form coined by de Bary. Webster's Dictionary gives *symbiont* as the preferred form (derived from a participle of the corresponding Greek verb) whereas *symbiote* is listed as a synonym or variant. Meyer (1925) and others have maintained that *symbiote* is the correct form. The Committee has consulted a member of the Department of the Classics, Harvard University, who has informed us that *symbiote* is derived from the Greek *sumbiotes,* meaning "one who lives with," "companion," "partner," whereas *symbiont* has no Greek original. He has stated further that the philologist would prefer *symbiote* which has a definite Greek original and is correctly formed in English. It may be pointed out that *symbiote* is the common form in French literature whereas most German, British and American writers use de Bary's *symbiont,* which possesses whatever advantage priority is able to cast into the etymological balance. The matter is apparently one of taste and usage rather than of correctness.

Formal recommendation by this Committee as to future usage of the term *symbiosis* seems hardly necessary. It is obvious that de Bary should not be cited as having defined it in the sense of strict mutualism. It may be maintained by some that wide usage has in fact thus narrowed the term, but this can hardly set aside the historically correct and still current usage in the broad sense. It follows that the present confusion necessitates the definition of the term whenever it is used.

References

Cleveland, L. R. 1926.—Symbiosis among animals with special reference to termites and their intestinal flagellates. Q. Rev. Biol., 1: 51–59.

De Bary, Anton. 1866.—Morphologie und Physiologie der Filze, Flechten und Myxomyceten. Wilhelm Engelmann, Leipzig.

1879.—Die Erscheinung der Symbiose. Karl J. Trübner, Strassburg.

1884.—Vergleichende Morphologie und Biologie der Pilze, Mycetozoen und Bacterien. Leipzig. (See also English translation by H. E. F. Garnsey, Oxford, 1887.)

Hegner, R. 1929.—*In* Hegner, Root and Augustine, Animal Parasitology. New York.

Hertwig, Oskar. 1883.—Die Symbiose oder das Genossenschaftsleben im Thierreich. Gustav Fischer, Jena.

1906.—Allgemeine Biologie. Gustav Fischer, Jena.

Meyer, K. F. 1925.—The "bacterial symbiosis" in the concretion deposits of certain operculate land mollusks of the families Cyclostomatidae and Annulariidae. J. Inf. Dis., 36: 1–108.

Nuttall, G. H. F. 1923.—Symbiosis in animals and plants. Report of the British Assoc. Adv. Sci., pp. 197–214.

Van Beneden, P. J. 1876.—Die Schmarotzer des Thierreichs. Internationale wissenschaftliche Bibliothek. Bd. XVIII. (There are various French and English editions of this work.)

Committee on terminology,

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